DESIGNING A CONTINUUM OF QUALITY EXTERNAL CAUSE OF INJURY INFORMATION IN QUEENSLAND: FROM AMBULANCE TO HOSPITAL

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ABSTRACT

Designing a Continuum of Quality External Cause of Injury Information in Queensland: From Ambulance to Hospital.

Injury prevention and control is a National Health Priority Area, with the annual direct cost of injuries across the Australian health sector representing a significant public health and economic burden. In order for injury prevention and control organisations to identify and implement mechanisms to effectively reduce injury events, it is vital that accurate and specific data detailing the circumstances surrounding the injury events be readily accessible. For injury prevention research, precise data regarding the causes of injury are essential for identification of existing and emergent trends in injury, design of prevention strategies to ameliorate injury risks, and assessment of the impact of implemented countermeasures. Detailed reliable data are equally important in injury control research, to evaluate the effectiveness of current treatments in reducing resultant morbidity and mortality, and for the development and refinement of clinical management strategies.

A key source of external cause of injury information in Australia is hospital morbidity data, coded using the ICD-10-AM classification system. A recurrent theme in the literature is that ICD external cause codes do not provide an adequate basis for contemporary injury research and surveillance (Harrison, 2000). Whilst there have been a number of significant issues identified as reducing the utility of this tool (Driscoll, Harrison, & Langley, 2004), no published studies were identified of the 'fit-for-purpose' of the codes to injury research. The aim of this project was to develop and trial a novel method to evaluate ICD-10-AM codes and clinical documentation for suitability for injury research activities; identify causes of poor information quality; and, develop strategies to enhance current external cause of injury data. Using a foundational injury epidemiological framework, Haddon's Matrix, an evaluation was conducted of the 'fit-

for-purpose' of ICD-10-AM external cause of injury codes, clinical documentation and coded injury data, for injury research.

To address the need for a more rigorous method of assessment of the quality of ICD-10-AM external cause of injury data to injury research, the current program of research involved three complementary studies. Study 1 established the utility of a novel Haddon's Matrix framework for defining and measuring information quality of injury data. The established measure of ICD data quality, based on a crude data completeness measure (Defined/Undefined code status), was compared to the proposed Haddon's Matrix framework; the models demonstrated equivalent completeness of coverage (proxy sensitivity) but the Defined/Undefined method was far inferior in terms of specificity. The results of this study indicate that the Haddon's Matrix model better reflects the complexity of the ICD code system for injury information.

In Study 2, the Haddon's Matrix 'fit-for-purpose' measure was employed to conduct an evaluation of Queensland hospital morbidity data to evaluate ICD-10-AM codes in application. The study involved a quantitative analysis of state-wide hospital morbidity data to identify the 'fit-for-purpose' of this data collection for injury research. Proportional utilisation of high and low quality codes was examined to identify priority areas for development. Within the QHAPDC dataset, numerous priority areas for data quality development were identified, with a lack of consistency evidenced across mechanism code blocks. A prominent weakness was the lack of Environment information, with less than half of all codes containing any detail.

The third study involved a detailed medical record review by an expert clinical coder. Evaluations were performed to assess whether poor information quality within the coded dataset was due to limitations of classification system, errors of coding, or a lack of information in the medical record. The precision of documentation sources for external cause of injury information was also assessed, with particular reference, based upon literature, to the potential for prehospital records to be better utilised to enhance the quality of hospital data for external cause of injury information. The largest contribution to error within the coded data was a lack sufficient detail within the medical records. However, ambulance records were identified overall as the highest quality source of information. Notably, cases that arrived at hospital by ambulance were 15.0 times more likely to contain Environment information.

This study is the first to employ a single evaluation framework to measure the 'fit-for-purpose' of all three key aspects of the clinical coding process (source documentation, code assignment, and code system structure) for injury prevention. Quantification of the impact of documentation sufficiency on coded data quality, and the substantial contribution of ambulance records to the overall quality of hospital morbidity data is a unique and notable contribution. Importantly, this study develops an evidence-based platform to inform and guide future developments in injury data classification development.

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List of Abbreviations - Glossary

AIHW	Australian Institute of Health and Welfare
EMS	Emergency Medical Services
ICD	International Classification of Diseases
ICD-10-AM	International Classification of Diseases (10th Edition) Australian Modification
MVC	Motor Vehicle Crash
NCCH	National Centre for Classification in Health
NCHIRT	National Centre for Health Information Research & Training
NHTSA	National Highway Traffic Safety Administration (USA)
QAS	Queensland Ambulance Service
QH	Queensland Health
QHAPDC	Queensland Hospital Admitted Patient Data Collection
WHO	World Health Organisation

STATEMENT OF ORIGINAL AUTHORSHIP

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

This doctoral thesis was conducted as part of a larger Australian Research Council funded Linkage Grant, "Developing and Enhancing the Quality of National Injury-Related Hospital Morbidity Data". The incorporation and examination of Haddon's Matrix in the context of this research, and the examination of the ambulance data was the unique contribution of the author. All statistical analyses presented in this doctoral thesis, and the authoring of this manuscript is the work of the student. Development of the project methodology, data collection for the medical record review study (Study 3), and writing of the journal articles related to the larger study (included in Appendices) were done in collaboration with the team of project investigators.

Signature: QUT Verified Signature

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Bailey & Nick - finally, the answer to your eternal question,

"Are you finished your PhD yet?" is: *"Yes!"*

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"Melius et utilius in tempore occurrere, quam post causam vulneratam quaerere remedium."

Cf. [c 1240 Bracton De Legibus v. x.]

(It is better and more useful to meet a problem in time
than to seek a remedy after the damage is done)

CHAPTER 1. INTRODUCTION

1.1 *Burden of injury*

Injury is a leading cause of mortality, morbidity, and permanent disability in Australia, accounting for an estimated 6.5% of the burden of disease in 2010 (Australian Institute of Health & Welfare, 2010). In Australia, the annual health cost of injuries is estimated to be $2.6 billion (Australian Institute of Health & Welfare, 2010), representing a significant public health and economic burden. Injuries have a high impact on society in terms of cost of healthcare, lost life years, productivity, and wellbeing, with the effects being pervasive, affecting people across the lifespan and often with lifelong effect. The high impact of injury on the community was recognised by the Federal Government in 1986, with designation of injury prevention and control as a National Health Priority Area (Australian Institute of Health & Welfare, 2013). Importantly, injuries are preventable and opportunities exist to reduce the burden of injury through the implementation of effective prevention strategies.

1.2 *Injury Prevention*

Many injuries are predictable and preventable. Accurate and comprehensive data pertaining to the circumstances surrounding injury events (e.g., the external causes of morbidity), are imperative for injury surveillance, prevention and control organisations to develop effective strategies to mitigate the impact of injuries (Langley & Chalmers, 1999a). Accurate and detailed data regarding the factors contributing to an injury are essential for identification of injury risk factors, allocation of resources to address leading issues, and evaluation of the effectiveness of injury prevention and control strategies. The development of effective injury prevention strategies is of key importance to the health system and community-at-large, as this has the potential to significantly reduce health care costs, and improve overall wellness (Garrison et al., 1997).

There are several stages to the identification and prevention of injuries. Firstly, injury surveillance is necessary to develop a body of data regarding injury events. Injury surveillance is the ongoing systematic collection, analysis, and interpretation of health data for the purpose of designing, implementing, and evaluating public health prevention programs (World Health Organisation, 2001). "The goal of injury surveillance is to provide accurate, unbiased information on who is injured, the circumstances of the injuries, the use of protective devices (or lack thereof), and the outcome" (Rivara, 2003, p.21). One of the key components of an injury surveillance system is the collection of information regarding the causes of injury events; this information is used to facilitate aetiologic research. Aetiologic research entails understanding the causes of injury to guide development of intervention programs that prevent injuries and/or mitigate their consequences (Rivara, 2003).

Once risk factors and causes of injury are identified, this information needs to be translated into action; this is the role of injury prevention and control agencies. Injury prevention organisations use aetiologic data, acquired through injury surveillance activities, to devise interventions to reduce the occurrence and impact of injury events (Haddon, 1980; Harrison, 2000). There are three types of injury prevention. Firstly, primary prevention involves both general and specific health-promotion measures that are targeted toward eliminating risk factors and preventing injuries. Secondary prevention involves rapid treatment following an injury event, and tertiary prevention aims to limit the short and long term consequences of an injury (Andersson & Menckel, 1995). All three forms of injury prevention are reliant upon accurate data, obtained through injury surveillance, to guide their activities.

A number of theoretical models exist for injury prevention. The Father of modern injury prevention is considered to be William Haddon, the designer of Haddon's Matrix, which is used by injury researchers to identify opportunities for prevention strategies. Haddon's Matrix employs a phased-factor approach to injury prevention by combining a cornerstone framework of epidemiology, the epidemiological triad of Host, Agent, and Environment, with a three-phase temporal factor to produce a nine-cell matrix. This matrix classifies injury events in more manageable segments to aid identification of prevention opportunities, and highlights the reliance that injury prevention activities have on high quality data regarding the circumstances surrounding injury events. (Runyan, 1998b)

1.3 *Injury Data and Coding Systems*

It is essential that reliable information regarding the circumstances of injury events be available to facilitate the identification, design, and evaluation of effective prevention strategies.

In Queensland, hospital morbidity data are coded using the International Classification of Diseases 10th Edition Australian Modification (ICD-10-AM). In theory, the use of a classification system such as ICD-10-AM to capture the circumstances leading to an injury should provide the information needed for injury prevention activities (Langlois, Buechner, O'Connor, Nacar, & Smith, 1995). However, a recurrent theme in the literature is that ICD external cause codes do not provide an adequate basis for contemporary injury research and surveillance (Harrison, 2000). There have been a number of significant issues identified as reducing the utility of this tool (Driscoll et al., 2004). Despite criticisms of ICD external cause of injury codes for injury research, there is a dearth of literature evaluating the quality of the ICD-10-AM code system for injury prevention research.

Deficiencies in hospital morbidity data and ICD-10-AM, the clinical classification system used in Australian hospitals, were highlighted. Despite criticisms of coder agreement and data completeness of the ICD-10-AM external cause of injury code system, there is a lack of studies evaluating the coded data beyond these two basic properties. If injury coding, and resultant injury datasets, are to be improved for the purpose of injury research, it is vital to undertake a comprehensive evaluation of this code system and factors that impact upon the quality of clinical coding.

The most widely used source of administrative data for injury research is hospital morbidity records, compiled from the information documented within patient medical charts. Morbidity data cover illness, injury, and reasons for contact with health services. For the purpose of injury research, hospital discharge records have detailed information on the nature, cause, and severity of injuries, and the records are collected objectively without the goal of ascribing blame or responsibility (Alamgir, Koehoorn, Ostry, Tompa, & Demers, 2006)

1.4 *Quality Framework for Injury Data*

Whilst 'data quality' is a term in widespread use, there is in fact very little agreement or standardisation as to what this term actually means, or how to measure it (Wand, 1996). A study by Wang, Kon and Madnick (1993) identified approximately 200 words to describe data quality (e.g. accuracy, completeness, currency, correctness, relevance). However, despite quality being represented as a multidimensional concept in the wider quality literature, only a narrow operationalisation of the term has been employed in the evaluation of data quality for ICD codes. The lack of a rigorously defined set of data quality dimensions (Wand, 1996), makes the customary measurement and comparison of data quality for ICD coded external cause of injury data problematic.

The concept of 'fit for use' has been widely adopted in the data quality literature, and is now the single most widely accepted definition of quality (Price, 2004). It emphasises the importance of taking a consumer viewpoint of quality because ultimately it is the consumer who will judge whether or not a product is fit for use (Deming, 1986; Dobyns, 1991; Juran, 1980a; Juran, 1980b). This thesis builds on the concept of 'fit for use' to develop an evaluation framework, based upon Haddon's matrix, to evaluate ICD-10-AM codes and clinical documentation for suitability for injury research activities, and to provide an evidence-based platform for future injury classification system and data development endeavours.

To improve the quality of injury-related hospital morbidity data for injury prevention, two main areas on which to focus resources are: 1) the development of external cause of injury codes to suit the purpose of injury prevention research; and 2) the provision of more detailed documentation from clinicians.

1.5 *Aims of the Thesis*

In summary, there are four key aims of this research:

1. To trial an epidemiological framework to assess the 'fit-for-purpose' of ICD-10-AM external cause of injury codes, and coded data, for injury research;

2. To evaluate the 'fit-for-purpose' of ICD-10-AM coded external cause of injury information within the Queensland Hospital Admitted Patients Data Collection;

3. To identify causes of poor information quality within the Queensland Hospital Admitted Patients Data Collection external cause of injury data;

4. To measure the completeness of injury information within medical records and evaluate the potential to enhance current external cause of injury data through improved utilisation of ambulance documentation.

The objective of this study was to conduct analysis of external cause of injury codes within the underlying ICD-10-AM classification system to:

1. Determine the data completeness of the ICD-10-AM code system for external cause of injury codes using 'traditional' Defined/Undefined code categorisations;

2. Determine the information quality of the ICD-10-AM code system for external cause of injury codes using a Haddon's Matrix conceptualisation of 'fit-for-purpose';

3. Compare the relative effectiveness (completeness of coverage, specificity, false negative, and false positive rates) of the Defined/Undefined 'data completeness' measure to the Haddon's Matrix 'information quality' conceptualisation;

4. Identify priority areas within the ICD-10-AM external cause of injury code system for quality improvement activities.

5. Evaluate the 'fit-for-purpose' information quality of ICD-10-AM codes in context by employing the proposed Haddon's Matrix framework; and

6. Identify priority areas for quality improvement based upon high frequency code blocks with low information quality.

7. To quantify the contribution of error sources in the coding process (i.e. code assignment error, documentation deficiencies, code system deficiencies) to information quality attrition in the coded dataset; and,

8. To measure the impact of ambulance documentation on the information quality of the resulting coded hospital morbidity dataset.

1.6 *Overview of the Thesis*

An overview of the literature regarding injury epidemiology, injury prevention, injury data collections, and injury classification systems, and discusses criticisms in the literature of current injury data collections is presented in Chapter 2.

Chapter 3 provides an overview of the data quality literature and provides discussion of the concept of data quality versus information quality and the implications of improved injury data for injury prevention research. Chapter 3 also discusses a novel method, based upon Haddon's matrix, to evaluate ICD-10-AM codes and clinical documentation for suitability for injury research activities. The examination presented within this chapter provides an evidence-based platform for future developments in injury data classification development work.

Chapter 4 (Study One) contains a descriptive analysis of the distributions of external cause of injury codes within the ICD-10-AM code system to evaluate the information quality of this code system applying the Haddon's Matrix conceptualisation of code content to assess 'fit-for-purpose'. The 'information quality' of the code system is evaluated using Haddon's matrix compared to the Defined/Undefined 'data quality' method previously used in studies of ICD code quality (Simeonsson, Scarborough, & Hebbeler, 2006). The methods of quality evaluation are compared in terms of their relative completeness of coverage, specificity, false negative and false positive rates. The available literature to-date has studied ICD-10-AM external cause of injury codes 'in action'; leading to a confounding of the results by other factors, aside from the code system structure, that impact data completeness. The analysis undertaken is of the underlying code system, absent of the impact of documentation characteristics or coder error.

Study 2 provides an analysis, using the Haddon's Matrix framework, of Queensland hospital morbidity data to evaluate ICD-10-AM codes in application, as presented in Chapter 5. The study involved a quantitative analysis of state-wide hospital morbidity data to identify the 'fit-for-purpose' of this data collection for injury research. Proportional utilisation of high and low quality codes was examined to identify priority areas for development.

The third study, a detailed medical record review by an expert clinical coder thesis is reported in Chapter 6. Narrative information within the source clinical documentation is categorised for presence or absence of Haddon's element and compared to ICD-10-AM coded outcomes to evaluate the level of detail regarding injury causation information in the medical documentation. Evaluations are performed to assess whether poor information quality within the coded dataset is due to limitations of classification system, errors of coding, or a lack of information in the medical record. The precision of documentation sources for external cause of injury information is also assessed, with particular reference to the potential for prehospital records to be better utilised to enhance the quality of hospital data for external cause of injury information.

Chapter 7 presents an overall discussion and implications of the project findings, study limitations, and implications for further research.

"Hindsight explains the injury that foresight would have prevented."

(Unknown)

CHAPTER 2. LITERATURE REVIEW – INJURY DATA

2.1 *Field of Injury Epidemiology*

Injury is an internationally recognised problem, carrying a high toll annually in terms of loss of lives, productivity and quality of life (Holder, Peden, Krug, Lund, Gururaj, and Kobusingye, 2001). In order to control and reduce the effect of this phenomenon, its causes and effects must first be elucidated.

2.1.1 Background

The scientific field of epidemiology involves the study of diseases affecting the health of populations, and explores their causal and correlational relationships to facilitate development of health management frameworks on a population-wide basis. The Greek physician Hippocrates is thought to be the father of epidemiology, being the first person known to have examined the relationships between disease occurrence and environmental influences (Merrill, 2010). Epidemiology is considered a foundational element of public health research, and is prominent in evidence-based medicine for identification of disease risk factors and determination of optimal treatment strategies. Epidemiology is a data driven exercise, involving study design, data collection and analysis around the incidence and causes of disease and injury conditions.

Epidemiology is based on the study of patterns of health, illness and related factors at a population level. It forms the foundation for public health research, and is used to generate an evidence-base for identifying risk factors for disease, determining optimal treatment approaches, and for devising preventative strategies. An epidemiological triad forms the traditional concept of disease causation: an external agent, a susceptible host, and an environment that brings the host and agent together to enable the disease to occur. A vector is an intermediary organism or object that transmits the disease without causing disease itself (see **Figure 1**).

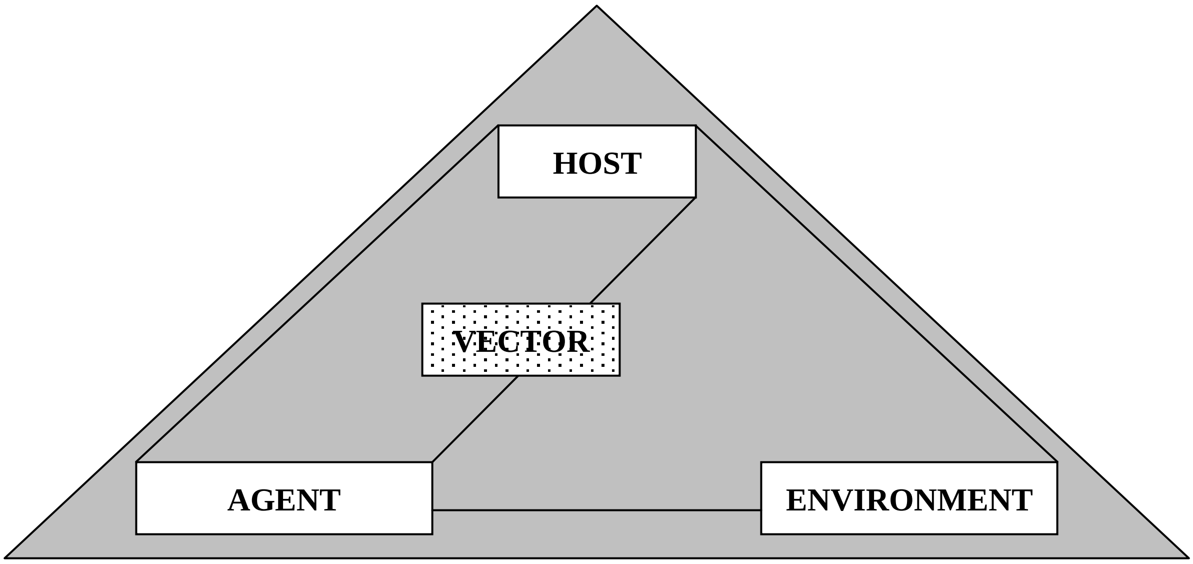

Figure 1 Epidemiological Triad

With specific reference to the field of injury, epidemiology involves study of the nature, incidence and causes of injuries, to promote the design of strategies to prevent, reduce or ameliorate the impact of injuries on individuals and the community as-a-whole. Injuries are avoidable - researchers estimate that up to 90% of injuries are predictable and preventable (Cushman, 1995). However, in order to prevent injuries, we must first understand their nature, occurrence, and causes - and this is dependent upon having a clear definition of exactly what comprises an injury.

2.2 *Context*

2.2.1 Definition of Injury

Defining what constitutes an ‘injury’ is not straightforward as there are many theoretical definitions abounding for ‘injury’. Whilst ‘injury’ is a commonplace term, the theoretical definition of injury is still a matter of substantial debate (Langley, and Brenner, 2004; Fingerhut, Harrison, & Mulder, 2004). The lack of consensus has been attributed to the fact that there is no scientific basis for the distinction between injury and disease (Langley, and Brenner, 2004; Fingerhut et al., 2004). There are a number of methods in use for defining an injury, but to distinguish between disease- and injury-based conditions, most theoretical injury definitions are based upon the source of the energy causing the damage.

Definitions may include the event, or mechanism, leading up to the injury (e.g. motor vehicle crash, cut, fall, etc.), the intent of the injury (e.g. unintentional, self-harm, assault), and can sometimes specify a timeframe for the injury occurrence, or the type of energy involved in the causation. Injuries can also be defined in relation to contributing factors (e.g. alcohol-related), the physical location where the incident occurred (e.g. home, street, public place), or the activity that was being undertaken at the time (e.g. sporting activity, working for an income) (Graitcer, 1992).

A brief theoretical definition for injury has been proposed as, “the physical damage that results when a human body is suddenly or briefly subjected to intolerable levels of energy” (Holder et al., 2001). However, Baker et al (1992) contended that it is not always a presence of energy responsible for an injury, but may in fact be due to a lack of energy (Baker, O'Neill, Ginsburg, & Guohua, 1992). Whilst the definition proposed by Baker et al. (1992) expanded the bounds to include injuries caused by a lack of energy, it continues to exclude ‘non-acute’, or repetitive strain-type injuries that often result from continual low energy exposures accumulating over time (Kumar, 2001). However, dependent upon the researcher’s topic of interest, these non-acute exposures may also be included in definitions of injury (Robertson, 1998). It is apparent that depending on the purpose of the user, injury can be defined in many ways, being difficult to entirely and concisely describe.

From a public health point-of-view, for the purpose of discussions regarding the causes and impact of injury upon an individual and the community, injury can be thought of as physical harm to a person’s body (e.g. broken bones, cuts, poisoning, burns). Such physical damage results from harmful contact between a person and an object, substance or environmental element (e.g. struck by car, cut by knife, bitten by dog, or poisoned by inhaled petrol), and can be as a result of intentional (e.g. assault, self-harm) or unintentional exposures to harm. This view of injury corresponds with, and expounds on, the National Committee for Injury Prevention and Control's (NCIPC) consensus definition for injury, developed in 1989. NCIPC define injury as "intentional or unintentional damage to the body resulting from acute exposure to thermal, mechanical, electrical or chemical energy or from the absence of such essentials as heat or oxygen". (U. S. Department of Health and Human Services, 1990) This is very similar to the standard definition adopted by WHO:

> "Injuries are caused by an acute exposition to physical agents such as mechanical energy, heat, electricity, chemical agents, ionizing radiations, which interacts with the body in quantities or rates exceeding the human tolerance threshold. In some cases (e.g. drowning or freezing), injuries are caused by the sudden lack of an essential element such as oxygen or heat." (Baker et al., 1992; Holder et al., 2001)

Even once a theoretical definition of injury is agreed upon, employing these definitions to describe a particular type of injury is also not always straightforward. Theoretical definitions of injury, such as the definition proposed by Baker et al. (1992) can be used to guide the identification of 'injury' as-a-whole, but can be limited in terms of how specific injury types can be identified for the purpose of research and analysis. For example, a theoretical definition that does not lend itself to operational application, to enable the selection of specific injury types and guide epidemiological and scientific exploration, is inherently limited.

Currently, many injury professionals are reliant on the ability of different injury data classification systems to be able to identify certain types of injuries. These injury data classifications are coded information structures used to aggregate data for storage, statistical analysis and reporting. Operational definitions, formed in such a manner, are not ideal as they are inherently limited by the structure, completeness and quality of the classification system in use. Additionally, depending upon the theoretical basis or framework employed in the development of such classification systems, the resulting operational and theoretical definitions of injury may not always be equivalent (Langley & Brenner, 2004), thereby making inter-study comparisons uninformative. In cases where there is incongruence between the theoretical and operational definitions, the bounds of the operational capabilities will supplant any theoretical considerations.

Langley & Brenner (2004), assert that operational definitions of injury, for the purpose of research, have most commonly been based upon the chapters of the International Classification of Diseases (ICD). ICD is the clinical classification system commonly used internationally to convert injury related information to a coded form. Under the current version of this code system (ICD-10), an operational definition of what constitutes an injury is based upon the code system's inclusion criteria for code assignment within the "Injury, poisoning and certain other consequences of external causes" chapter (Chapter XIX), or "External Causes of Injury and Poisoning" chapters (Chapter XX) of ICD-10 (World Health Organisation, 1992). In the previous version of the code system (ICD-9), still in use in some areas internationally (notably USA), injury codes were those selected from within the E-code chapter (code range 800-999) (World Health Organisation, 1977). Arguably, if such operational definitions are to be widely formed and applied for the basis of injury research and prevention applications, it would seem essential to evaluate the 'fit' of such classification systems for the purpose to which it is being employed. There have already been calls made by experts within the injury field to revise both the theoretical and operational definitions of injury (Langley & Brenner, 2004; Boufous & Williamson, 2003). Accordingly, this necessitates the revision of ICD external cause of injury codes to ensure concordance between the classification system's structure and content, and the injury definitions employed.

One issue of great debate associated with the adoption of the ICD-10 operational definition for injury is the inclusion of injuries resulting from 'complications of surgical and medical care' with 'community-based injuries' (i.e. all other injuries, not resulting from medical care) in the enumeration of injury-related hospital admissions. Depending upon the purpose of inquiry, this may well not match with the employed theoretical definition of injury. From a public health point-of-view these two broad injury types are substantially different aetiologies that require distinctly different approaches to prevention. It is on this basis that arguments for the exclusion of 'complications of surgical and medical care' codes from general studies of injury epidemiology are made (Berry & Harrison, 2007). Prevention of community injuries concerns targeting the general population regarding a wide range on injury mechanisms and risk factors. These injuries often occur in relatively uncontrolled and complex environments with multiple risk factors, and in many cases there is little immediate incentive (bar the risk of injury) for individuals to alter their behaviour. Comparatively, prevention of medical injuries occurs within the relatively controlled healthcare setting amongst healthcare professionals who are bound by a duty of care to protect the safety of their patients.

In Australia, the National Injury Surveillance Unit (NISU), a peak research body for injury epidemiology and prevention, has adopted an approach to the analysis of injury-related hospital admissions of separating 'complications of surgical and medical care' (code range T80–T88) from 'community injuries' (Chapter XIX code range S00–T75, T79; Chapter XX code range *V00-Y98*), and presenting their analyses independently (Berry & Harrison, 2007).

2.2.2 Burden of Injury

"The risk of injury is so great that most persons sustain a significant injury at some time during their lives."

(U.S. Department of Health and Human Services, 2000)

Worldwide, injuries account for a large proportion of the public health burden, and the proportion of injury burden for both low and high income countries is expected to increase substantially by the year 2020 (Garrison et al., 1997). Due to the already large and increasing community impact posed by injuries, decreasing the injury burden globally has been described as among one of the main challenges for public health in the 21st Century (Krug, 2004).

Worldwide, injuries accounted for approximately 10% of mortality in 2010, equating to approximately 5.1 million deaths (Lozano et al., 2013, p38). Injury does not discriminate on the basis of age, with injury patterns showing peaks in incidence across the lifespan (Bright, Begg, & Harper, 2006; Queensland Health, 2009). The impact on the community of these lives lost is devastating, particularly given that many of these lives will be lost from relatively young, fit people within the community. Additionally, for those people who survive injuries, there are lifelong effects. Worldwide in 1990, injuries accounted for 76.1 million years of productive life lost due to disability (Garrison et al., 1997).

2.2.2.1 **Australia**

Whilst the effects of fatal injuries are widespread and undeniably horrific, non-fatal injuries resulting in hospitalisation are more common than fatal injuries. In Australia, it has been conservatively estimated that for every one injury-related death there are 40 injured people who require hospitalisation; 350 individuals who present with an injury to an emergency department; and 1,350 injury presentations to a general practitioner (Harrison & Tyson, 1993). Thus, injury morbidity equates to not only a large community burden in terms of loss of productivity, pain and suffering, it also results in a heavy burden on the healthcare system. In real terms, in 2007-08 ‘community injuries’ equated to an estimated 400,000 hospital admissions, representing 5.4% of all hospitalisations, with an average hospital stay of 4.1 days (Australian Institute of Health & Welfare, 2010). This equates to an Australian population-standardised rate of 1,829.4 injury-related hospital admissions per 100,000 persons. Additionally, injury hospitalisations are costly, accounting for approximately 8% of the total direct costs for all diseases each year; it is estimated that health costs associated with injury are in the order of $2.6 billion nationally (Department of Health & Ageing, 2007).

For many injuries the impact of the initial event persists long after the physical manifestations have healed. High severity injury cases, that is, those presenting an imminent threat-to-life, are likely to have an especially large, and persisting, effect on the patient, their family, friends and workplace. Injuries such as burns, fractures and spinal injuries can have long-lasting and profound effects on individuals’ quality of life and wellbeing. National morbidity data published by AIHW estimates a fifth of all hospitalised injury cases to be of high-threat-to-life (Australian Institute of Health & Welfare, 2010). Accordingly, results from the National Health Survey conducted by Australian Bureau of Statistics estimated that in 2007-08 approximately 2.4 million Australians were suffering a long-term health condition as the result of a previous injury (Austrlian Bureau of Statistics, 2009).

Given the tremendous importance of injury to the community in Australia, injury is one of seven key health areas identified by the Commonwealth, state and territory governments as National Health Priority Areas. This recognises the potential for gain through preventing or lessening the impact of an injury.

2.2.2.2 **Queensland**

Injury is a major contributor to the overall burden of disease in Queensland. In 2003, intentional and unintentional injury was the cause of 7.1 per cent of the total disease burden for the state (Queensland Health, 2009). In fact, injury rates in Queensland are amongst the highest in Australia. In 2004-05, rates of hospitalised injury cases for residents of Queensland (1,908.4 per 100,000 population) were substantially higher than the Australian average (1762.8 per 100,000) (Bradley & Harrison, 2008). The report authors note that these hospitalised community injury rates were calculated according to the state of usual residence of the patient. Whilst this will not accurately reflect cases where the person has been hospitalised outside of their state of usual residence (e.g. while on holiday), given difficulties in acquiring population data at state-level, this method is considered to be the best measure of the distribution of serious injury cases.

In Queensland, injury is responsible for approximately 10% of all hospital admissions, and 40-60% of emergency department attendances (Royal Australian College of Surgeons, 2006). Injury results in over 40,000 hospital admissions in Queensland each year, and Queensland's death rate from injuries is higher than the national average (Pike, Muller, Baade, & Ward, 2000). Additionally, injury is pervasive, affecting all sectors of the community with three peaks in injury incidence throughout the lifespan: childhood; young adulthood (particularly males); and older age (Bright, Begg & Harper, 2006; Queensland Health, 2009). Recent figures from Queensland concerning the current rates of injury show that while deaths from injury have declined, rates of hospitalisation for many injuries have increased over the past decade (Bright, Begg & Harper, 2006; Queensland Health, 2009). As such, reducing the burden of injury is an important public health issue for the Queensland community, and was identified as a corporate priority by the Queensland Health in the year 2000.

2.3 *Injury Prevention*

"Prevention is better than a cure"

(Desiderius Erasmus; c.1466-1536, Dutch humanist)

Whilst injury events are common occurrences in modern societies, they are by no means unavoidable. It is important to recognise that injuries are preventable events, and that by developing and implementing effective preventative programs, there are significant opportunities available for reducing their burden (Bangdiwala & Viadro, 2000). The injury literature shows that patterns of injury can be identified on the basis of factors such as age, gender, injury cause, social characteristics and geographic location (Rivara & Mueller, 1987). If identified, risk factors such as these represent vital opportunities for devising and implementing effective prevention strategies.

The field of injury prevention has identified three distinct phases for prevention opportunities (Pless & Hagel, 2005), either through injury avoidance, impact reduction or improved treatment of injury. The three stages mimic the chronological nature of injury events:

- Primary prevention, which refers to prevention of the initial event by reduction or removal of risk factors (e.g. installing traffic lights at dangerous traffic intersections);

- Secondary prevention involves countermeasure development to reduce the severity of an injury event (e.g. compulsory wearing of seatbelts);

- Tertiary prevention, which introduces injury control through refinement of advanced medical and surgical techniques for the treatment and management of injuries. Last's definition of tertiary prevention, also referred to as 'injury control', is defined as "measures … to reduce or eliminate long-term impairment and disabilities, minimise suffering … and to promote …

> adjustment to irremediable conditions." (Last, 1988 cited in Pless & Hagel, 2005, p.183).

It has been asserted by trauma specialists, Sasser, Varghese, Kellerman and Lormand (2005) that, "the optimal way to reduce life threatening injuries is through primary prevention efforts that decrease the incidence and severity of injuries" (p.1). As such, significant attention and resourcing should be given to the development and implementation of injury prevention methods to reduce the economic and social burden of injury on the community.

2.3.1 Background

Injury is an area in which improvements to community and health outcomes are achievable. There are many examples available of successful intervention strategies that have dramatically reduced the toll of injury on lives, both in terms of death and disability. Some well-known examples of effective injury prevention strategies include backyard swimming pool fencing, home smoke alarms, restraints in vehicles, and bicycle helmet programs (Towner, Dowswell, & and Jarvis, 2001; Thompson & and Rivara, 2001). Injury prevention can involve education strategies to alert the community to injury risks and to disseminate strategies for individuals to avoid or reduce the personal impact of injuries (Finch, Mahoney, Townsend, & Zazryn, 2003; Marsh, Connor, Wesolowski, & Grisoni, 2000; Dannenberg, Gielen, Beilenson, Wilson, & Joffe, 1993; DiGuiseppi & Roberts, 2000; Zhao, Qiu, Qiu, & Zhongguo, 2006). Strategies may involve the introduction of legislation or policy, and subsequent legal enforcement of such, to outlaw dangerous behaviours and practices (Mitchell, McClure, Williamson, & McKenzie, 2008; Gielen & Sleet, 2003; Hammond, 1993; Davis, Bennink, Pepper, Parks, Lemaster & Townsend, 2006). Engineering strategies may be employed to alter hazards within the environment, or to design protective measures to reduce the impact of injuries when they do occur (Hudson, Thompson, & Mack, 1999; Parkin & Howard, 2008; Porta, Handelman, & McGovern, 1999).

Information on the cause of an injury is seen as being a central concept for injury prevention (Strategic Injury Prevention Partnership, 2004). By identifying the causes of injuries, and then removing or reducing individuals' exposure to these risk factors, injuries can be prevented. In order for effective injury prevention strategies to be developed, it is necessary to have a strong evidence base, the linchpin being accurate data collections, on which to design interventions, new policy or legislation, and education strategies (McKenzie & McClure, 2010).

2.3.2 Key Public Health Theories

The field of injury surveillance and prevention sits firmly in the public health field. Injury is a public health issue, impacting on the population as a whole. Injury prevention has proven to be most effective when based upon a strong understanding of the problem and its contributory factors (National Public Health Partnership, 2005). Thus, a broad understanding of, and selection of, appropriate theoretical models is fundamental to the formulation and success of resultant prevention activities.

Whilst a variety of injury prevention models have been proposed (Christoffel & Gallagher, 1999; Cohen & Swift, 1999; Lett, Kobusingye, & Sethi, 2002; Reason, 1997), there are three key public health models used to conceptualise the identification of risk factors and preventative strategies for injury: Haddon's Matrix, the Public Health Model, and the Social Ecological Model. Haddon's Matrix and the Public Health Approach, as presented following, have been dubbed the "two most important models utilized in injury control" (Lett et al., 2002). Both these models provide a framework for data collection, and provide guidance as to how it should be grouped and analysed in order to identify risk factors and develop countermeasures.

2.3.2.1 **Haddon's Matrix**

Dr William Haddon Jr., is widely considered the father of modern injury epidemiology, and has been highly influential in arguing for a scientifically driven approach to injury control (Runyan, 2003). His work was an elaboration on that of two researchers before him. The first, Herbert Heinrich, a pioneer in industrial safety, proposed in the 1920's that injury events occurred much like a domino reaction (Heinrich, Petersen, & Roos, 1980). His theory, denoted the "domino theory of accident causation", stated that an incident resulting in an injury or other damage is the result of a causal chain of events. He asserted that, therefore, the removal of a single element of the causal chain (represented by a 'domino') would prevent the sequence from completing and thereby prevent the injury. Factors that he considered to be 'dominos', or part of the causal chain were related to the social and physical environment, mechanical equipment, and the individual.

The work of Heinrich was followed in the 1940's by John Gordon who was the first public health professional to consider injury as an ecological issue. He likened injuries to disease and proposed that injuries occurred as a result of a combination of three key factors, those of the epidemiological triad: the host or person; the agent; and the environment in which the host and agent interacted (Gordon, 1949). It was on this concept that William Haddon based his work, which originated in the field of traffic safety injury epidemiology and prevention. Haddon proposed a two-dimensional matrix designed to facilitate the development of injury prevention strategies (Haddon, 1980). Haddon's Matrix has now been recognised as the prominent injury prevention model for near on three decades (Runyan, 2003).

Haddon's Matrix provides a multidimensional approach to understanding the contributing factors to injury (Runyan, 2003). The matrix is comprised of a 3 x 3 grid, resulting in 9 cells. Each cell represents a unique description of injury causation and thereby an opportunity for targeted intervention. The matrix has been refined to its current form (**Figure 2**), where three rows contain the traditional epidemiological triad of:

- Host: person affected by the injury;

- Agent: energy (i.e. kinetic) transferred to the host by either an inanimate vehicle (e.g. firearm, motor vehicle) or animate vector (e.g. assailant);

- Environment: physical or social surroundings that contribute to the occurrence or potential occurrence of injury.

	Pre-Event	Event	Post-Event
Host			
Agent/Vector/Vehicle			
Environment			

Figure 2 Haddon's Matrix

Source: Haddon, W. Jr. (1980). Advances in the Epidemiology of Injuries as a Basis for Public Policy. *Public Health Reports*, *95*(5), 411-21.

Haddon paid considerable attention to the concept of "agent", derived from the epidemiological triad. Traditionally the agent had been understood to be an "object" that could lead to harm, however he later substituted "energy" for "object" in the role of the injury agent. Modern definitions of injury have developed to reflect this concept, and injurious objects were then redefined as vectors or vehicles for the energy source (i.e. carriers of potentially harmful energy).

The three columns of the matrix are labelled with a time continuum that represents the different phases of an injury: pre-event; event; post-event (Barnett, Balicer, Blodgett, Fews, Parker & Links, 2005; Demetriades et al., 1998; Haddon, 1972; Haddon, 1980). This phased approach divides the resulting strategies for prevention into primary, secondary and tertiary prevention. As discussed earlier, primary (pre-event) prevention efforts aim to avert an incident before it occurs or has the opportunity to cause an injury (e.g. legislation). Secondary prevention strategies aim to prevent or limit the severity of an injury (e.g. use of protective measures such as seat). Tertiary prevention aims to limit the consequences of an injury that has already occurred, such as through the timely availability of emergency medical services, definitive treatment, and rehabilitation services.

The combination of the epidemiological triangle, which emphasises the interactive nature of host, agent and environmental factors, with the element of time highlights that there is not just a single opportunity for intervention. Prevention strategies can be targeted at any of a number of risk factors at several points in time. Each cell of Haddon's matrix represents unique opportunities for prevention and control. The matrix can be used to identify a range of preventive measures across the three stages of an injury event.

An example of the use of the matrix for the prevention of an injury involving public playground equipment is shown in **Figure 3**. Within this example, prevention strategies for the prevention of events can be allocated to one (or more) of the 9 cells of Haddon's matrix. The pre-event strategies would focus on the prevention of unsafe and inappropriate use of play equipment; this may be in the form of safety campaigns, routine supervision of such facilities or transfer of responsibility and culpability for such behaviour to the parents in cases involving youths. During the event, prevention strategies focus on safeguards in the environment; this may include the use of soft-fall materials as a ground covering. After the event has occurred, the strategies would be focussed on reducing the morbidity of the event by ensuring prompt medical treatment. .

	Pre-Event	Event	Post-Event
Host	Teenage youth on childrens' play equipment; safety chain not engaged	Hits head on ground	Skull fracture
Agent/Vector	Swing being pushed too hard	Chain arm supporting swing seat breaks	Broken play equipment in public area
Environment	Public park	Hard ground, no soft-fall material	Distance from medical assistance

Figure 3 Haddon's Matrix Conceptualisation of an Injury Event

The matrix provides a static view of injury causation and response, and in doing so, highlights opportunities and needs for documentation and data collection of specific elements of the injury event (e.g. Host, Agent, Environment factors), to facilitate completion of the component matrix cells.

2.3.2.2 **Public Health Approach**

Haddon's Matrix provides a valuable structure for injury surveillance with regards to the details that should be collected about an injury event. However, the model has been criticised for lacking a plan of action about how injury prevention measures should be designed, implemented and monitored. An alternative model, that addresses this issue, is the Public Health Approach. The Public Health Approach is not limited in use to injury prevention; its scientific principles have been described as the "building blocks upon which successful community-based interventions of any type are structured" (Wright & Edgerton, 2003, p.127). This framework consists of a hierarchy of four levels: surveillance, risk factor identification, intervention evaluation, and program implementation (Lett, Kobusingye & Sethi, 2002; Rosenberg & Fenley, 1990).

The first step of this model is the collection of information to quantify the extent of an issue. Once this is accomplished, the second step involves identification of risk and protective factors; thirdly existing effective injury prevention strategies are identified. The fourth, and final step, is the implementation of successful prevention strategies (Christoffel & Gallagher, 1999). The benefit of this approach is the emphasis on the use of a scientific methodology to address injury. Steps proceed sequentially; systematically building upon the data and knowledge accrued at each prior step (Lett et al., 2002). The Public Health Approach has been used for development of both general public health, and specific injury prevention programs. The model's strength is its basis in evidence-based practice, with interventions being progressively constructed dependent upon the available data and evidence. The Public Health Approach (PHA) presents a plan for the process that should be engaged to put data into action, something that Haddon's Matrix has been criticised as lacking (Lett et al., 2002).

Surprisingly, given the model's basis in evidence-based practice there is no inclusion of a step to evaluate the implemented interventions i.e. no system feedback. Additionally, whilst the PHA provides a comprehensive strategy by which to identify, develop and implement injury prevention strategies, it does not provide detailed guidance as to what data need to be collected in order to provide this comprehensive evidence base for countermeasure design.

2.3.2.3 **Other Models of Injury Prevention**

2.3.2.3.1 Social Ecological Model

A third theoretical model that has been applied to the field of injury prevention research is the Social Ecological model developed by Bronfenbrenner (1979). This model originates within the sociological and psychological disciplines, and as a result focuses largely on individuals, their behaviour and interaction with the socio-cultural environments (Cohen, Miller, Sheppard, Gordon, Gantz, & Atnafou, 2003). The Social Ecological model is more compartmentalised than the PHA or Haddon's

Matrix, involving interactions between four factors: the individual, relationships, community and society. This model centres on the individual and their interactions with discrete entities. There is no explicit inclusion of any temporal elements, nor explicit provision for the physical environment, both of which are important factors in aetiologic research of injury outcomes.

2.3.2.3.2 Combined Haddon's Matrix and PHA

In order to address the criticisms of Haddon's Matrix and the PHA model of injury prevention, Lett et al (Lett et al., 2002) proposed a combined model incorporating the two theories. The result is a multifactorial, three-dimensional model of injury prevention that is designed to be comprehensive in addressing the prevention of injuries. The problem with this model is that it is so comprehensive that it is too unwieldy to be operationally functional in guiding systematic and reliable data collection and analysis. In order to gain a comprehensive picture of a single injury mechanism (e.g. motor vehicle crashes), 48 individual cubes of information would require completion, analysis and integration.

2.3.2.3.3 Spectrum of Prevention

Developed by Cohen and Swift (Cohen & Swift, 1999), this model outlines a systems approach to injury prevention. This framework details six levels, to be used in association:

1. strengthening individual knowledge and skills through provision of prevention information from a person in an authority position (e.g. a medical officer);
2. promoting community education to increase general awareness in the population (e.g. TV campaigns);
3. educating providers through mechanisms such as training and professional development activities;
4. fostering coalitions and networks to expand partnerships in order to develop and finance prevention activities;

5. changing organisational practices through encouraging agencies to adopt and implement injury prevention strategies (e.g. work safe practices);

6. influencing policy and legislation through campaigning for changes in state or national legislation to enhance prevention efforts (e.g. advocacy role).

While this model provides a multifaceted approach to the implementation and promotion of injury prevention efforts, it does not provide any acknowledgment of the centrality of quality information to the achievement of these goals. Nor does it provide any guidance by which to access, collect or evaluate the quality of injury data for prevention efforts.

2.3.2.4 **Theoretical Frameworks in Context**

Current theoretical frameworks for injury prevention need be considered in the context of how they support and facilitate the collection and analysis of injury information to inform prevention activities. Injury prevention is, at its core, a data driven exercise. If prevention strategies are to be targeted and effective they require a strong evidence-base. (National Public Health Partnership, 2004) This evidence-base is amassed through the collection and analysis of accurate and specific data regarding pertinent aspects of the injury event.

As discussed previously, the availability of accurate and specific injury data is pivotal to the development and implementation of effective injury prevention and control strategies. Accordingly, the centrality of robust data collections to the field of injury prevention is highlighted in the Injury Prevention and Evaluation Cycle diagram developed by Soubhi et al., (1999). This model includes seven steps involved in the identification, development, application and evaluation of injury prevention strategies. **(Figure 4)** The diagram emphasises the reliance on data at each point. The circular nature of this diagram highlights the ongoing nature of injury prevention, with reductions being achieved in discrete steps, and the continual monitoring of injury occurrences necessary to sustain reductions (Soubhi et al., 1999). Injury prevention is a continuous process requiring accurate data as the central hub of the process, to which the other aspects are tethered.

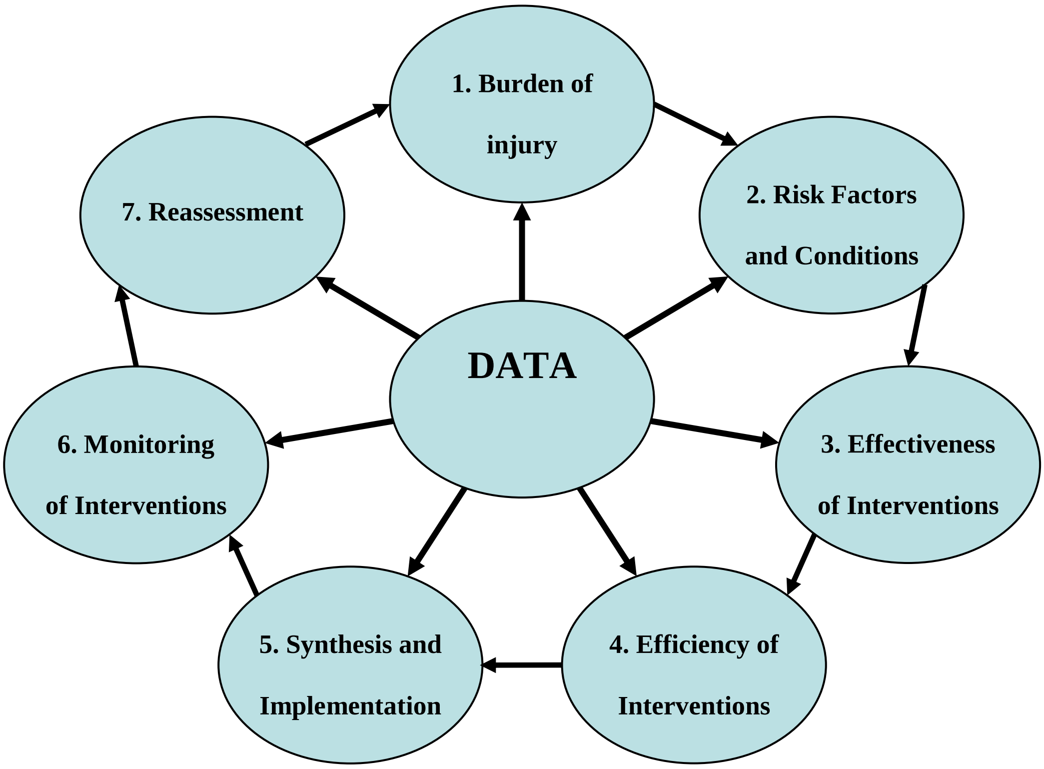

Figure 4 Injury Prevention and Evaluation Cycle (IPEC)

Source: Soubhi, H., Raina, P., Chong, M., Turcotte K, Babul, S., Olsen, L. & Scanlan, A. (1999). *Unintentional injuries in British Columbia: Trends and patterns among children and youth 1987-1996*. BC Injury Research and Prevention Unit, Vancouver, BC.

The Public Health Approach (PHA), when applied to the issue of injury prevention provides a comprehensive strategy by which to identify, develop and implement injury prevention strategies. Whilst this model acknowledges the foundation knowledge base of injury data, the focal point of the model is how to systematically implement a prevention program to address an issue, once given knowledge of the issue within a community. The model does not focus to any extent on the specific data elements that are required to identify injury prevention targets, nor does it provide guidance as to structure or evaluate injury data collections for injury prevention. The Spectrum of Prevention model proposed by Cohen and Swift (1999) does not include any discussion of the importance of injury data to prevention activities, nor therefore any requirements regarding injury information collection, coding and analysis.

Whilst the socio-ecological model identifies four interactive injury elements, and therefore potentially four prospects for structuring data collection, Haddon's matrix identifies all these four elements and more. The 'host' factors within Haddon's Matrix translate to 'individual' factors within the Social Ecological model; Haddon's 'Agent' factors of victim and perpetrator include the Social Ecological 'relationship' component; and Haddon's 'Environment' encompasses the 'community and society' factors. Haddon's Matrix also encompasses elements not included in Bronfenbrenner's model, namely the physical environment (Gillam, 2004). Inclusion of the physical environment element is essential to the framework of this study. Environments are a major component in the circumstances surrounding an injury, and have a strong role in determining injury risks, as well as opportunities for injury prevention (National Public Health Partnership, 2005).

Haddon's model also conceptualises the continuum from prevention through to rehabilitation via the temporal component of the model. Haddon's model, in its design, promotes injury research being viewed as a continuum, with injury events consisting of several integrated phases, and opportunities for interventions existing at multiple points along the continuum. The time continuum of Haddon's matrix facilitates a collaborative approach, involving cross agency co-operation and encouraging a broader viewpoint of injury research than that of a single agency or organisation (Runyan, 2003). The unifying characteristic introduced by the temporal component of Haddon's Matrix is akin to a continuum view of healthcare, with treatment occurring in several integrated stages (e.g. prehospital emergency services, hospital admission, rehabilitation), and each of these stages presenting unique attributes for informing and implementing prevention strategies across the fields.

Haddon's Matrix integrates the concepts of primary, secondary, and tertiary injury prevention (prevention, mitigation and control) with the concepts of the host/agent/environment interaction, to present multiple opportunities for delivering public health interventions to target injury occurrence (Runyan, 1998). Concurrently, the grid matrix, formed by the use of the epidemiological triad (Host, Agent, and Environment) with the three temporal phases of prevention, provides precise guidance regarding elements for which accurate and comprehensive information is required for injury research. Each cell of the matrix can represent either a prevention opportunity, or a data need (e.g. data collections should be structured to collect information on Host, Agent and Environment aspects of the injury across the three time phases [Pre-event, Event & Post-event]).

Whilst an attempt was made by Lett et al., (2002) to combine Haddon's Matrix and the PHA model in order to benefit from the merits of each theory, the resulting model was complicated and unwieldy. The three-dimensional model that was proposed consisted of a large number of discrete cells for collection and analysis. Not only would this result in an onerous workload in terms of data collection and management, it would also likely lead to fractured data collections with key descriptions of an injury event potentially being distributed in multiple valid permutations across the considerable data fields. With any model for injury prevention and injury data there is a need to balance specificity (i.e. having sufficient detail about cases so as to be useful to injury prevention researchers), with the utility of the system (ie. the more codes available, the larger and more cumbersome the code system to navigate, use and analyse). Haddon's Matrix provides a comprehensive theoretical framework for injury surveillance, and injury data collection structures to identifying risk factors and risk conditions for injury. Haddon's model has been demonstrated to provide a valuable tool to guide development of systems that inform understanding of the processes by which injuries occur, and how they can thus be prevented (Runyan, 2003).

2.4 *Injury Data Collections*

2.4.1 Available Sources of Injury Data

There are many diverse sources of data available regarding the nature and circumstances of injury. Often this information is collected outside of the health system using varying coding schemes (Boufous & Williamson, 2006), the information differing by level of injury severity (Graitcer, 1992; Rahman, Andersson, & Svanstrom, 2000; Thacker & Berkelman, 1988). Examples of common data collections used for injury surveillance include coronial records and other mortality data collections, morbidity data collections such as hospital admission records, emergency department presentations, trauma registries, ambulance records, General Practice (GP) data systems, first aid provider records, police reports, newspaper articles, population surveys, insurance claims, workers' compensation and Occupational Health and Safety (OHS) records, and a multitude of other specialist agency reports (Adirim et al., 1999; Butler, Kariminia, Trevathan, & Bond, 2004; Christoffel & Gallagher, 1999; Horan & Mallonee, 2003; Rainey & Runyan, 1992; Thacker & Berkelman, 1988).

Injury data collections need to capture information regarding the types of injuries that are occurring, why they are occurring, and to whom, where and when (Mitchell et al., 2008). Many of the sources of injury data are administrative databases constructed and collected for purposes other than injury prevention (namely billing), thus injury research applications are a secondary use for this data. Most injury surveillance is conducted using such collections, which may not have the capacity to provide the core information necessary for injury surveillance (i.e. what injuries occurred where to whom, when they occurred, and why) (Graitcer, 1987; Ing et al., 1985) and, therefore are not ideal for injury surveillance purposes. Additionally, the way in which this information is recorded or represented is quite disparate across collections. This lack of standardisation and comparability across collections makes integration difficult, and compromises the ability to accurately conduct analyse and derive knowledge from the data (Boufous & Finch, 2006). However, the proliferation of electronic data storage, allowing rapid access to large datasets, has increased the importance of administrative databases for research (Boufous & Finch, 2006). It is thus vital that such data sources be evaluated, and improved in terms of data quality so that they can be effectively utilised for integrated injury research purposes.

There are also numerous data collections that only collect information on injuries involving sub-groups of the population, by geography, demography or injury mechanism (e.g. motor vehicle crashes, pool drownings, burn injuries, child-related injuries, etc.). Targeted information regarding injuries can be obtained from special collections such as surveys and questionnaires (e.g. National Health Surveys, random telephone interviews); dedicated databases (Australia Transport Safety Bureau, Queensland Injury Surveillance Unit, Queensland Trauma Registry); government departments (e.g. Workcover); private sector (e.g. insurance industry); and, specialist units (e.g. Emergency Departments, acquired brain injury treatment centres), that are designed to derive specific information regarding injuries. However, these data sources have a number of weaknesses, namely that they are often costly to set up and maintain, can only provide data on a sample of the population and therefore have incomplete coverage, and only contain cases with limited specific types and/or causes of injury.

2.4.2 Hospital Morbidity Data

The most widely used sources of administrative data for injury research are hospital morbidity records, compiled from the information documented within patient medical records. Morbidity data cover illness, injury and reasons for contact with health services. For the purpose of injury research, many countries (including AUS, NZ, etc.) hospital discharge records have detailed information on the nature, cause and severity of injuries, and the records are collected objectively without the objective of ascribing blame or responsibility (Alamgir et al., 2006). While the USA does not collect these data at a national level, but for a sample of hospitals, recent work has argued for more widespread collection of external care data at a national level (National Center for Injury Prevention and Control, 2009).

These data are employed for a wide variety of applications, including: public safety and injury surveillance and prevention; public health disease surveillance and disease registries; public health planning and community assessments; public reporting for informed purchasing and comparative reports; quality assessment and performance improvement; health services and health policy research applications; informing policy deliberations and legislation (Schoenman & Sutton, 2005). Information obtained from the analysis of such datasets is often used to identify areas to which injury prevention resources should be directed (Graitcer, 1987; Graitcer, 1992; Stone & Morrison, 1998).

External cause of injury information is included in morbidity data collections specifically for the purpose of research and planning. Unlike diagnosis and procedure codes within the collection, which are used for generating Diagnosis Related Groups (DRG) for funding calculations, external cause of injury codes have no funding implications for health services. Information from injury morbidity data collections can be used to describe the epidemiological profile of specific injury events. However, they form part of an administrative dataset, the use of which for research on a general basis is a secondary application of the data. Consequently, the ability to produce both a comprehensive and accurate profile of specific injury events is dependent on the type of information available and also on the quality of this information. The information available in injury mortality and morbidity data collections can vary. For example, for some injury mechanisms, such as motor vehicle crashes (MVCs), where data has been collected on these events for many years, data collections are often further advanced in terms of the detail recorded compared to other injury events, such as work-related injuries.

It has already been noted that a key aspect of any injury surveillance system is information on the circumstances of the injury event. It has been claimed that hospital discharge data contain detailed information regarding the outcomes of injuries there is insufficient detail available regarding the circumstances of injury (Boufous & Finch, 2006). Limitations of coded hospital discharge data can feasibly include miscoding (i.e. assignment of an incorrect code in error), a lack of detailed codes (e.g. use of general codes providing only broad description), and limited data quality (e.g.. missing data, contradictory information, etc.). However, in defence of this data source for injury prevention research, it has been noted that "although discharge abstract data lack the richness of primary data, these data are the most accessible comparative data source for examining all patients admitted to a hospital" (Schwartz, Gagnon, Muri, Zhao, & Kellogg, 1999, p.292).

Analysis of nonfatal injuries, as well as fatalities, allows for a more informed prioritisation of injury control efforts and may lead to more targeted approaches to injury prevention (Wadman, Muelleman, Coto, & Kellermann, 2003). Information from morbidity data is widely used for formulation and evaluation of public health policies, as well as the allocation of resources to high priority areas. The health sector has been a powerful advocate in the development of injury policy in Australia, including making evidence-based recommendations aimed at improving information obtained from injury data collections (Department of Health & Ageing, 2005; Strategic Injury Prevention Partnership, 2004).

Coded hospital discharge data has long been recognised as potentially one of the most effective and efficient means available to collect data needed to prevent and control injuries (National Center for Injury Prevention and Control, 2009), particularly given the comprehensive population-based coverage of hospitalisations (Schoenman & Sutton, 2005; Zhan & Miller, 2003). These datasets also have a number of other characteristics that make them appealing to use, namely: they are readily available; relatively inexpensive to acquire compared to special collections such as surveys and medical record abstractions; more reliable than other data collections such as patient self-reports or clinician reporting for specific disease surveillance; and, can be collected across multiple years to enable trend analysis (Schoenman & Sutton, 2005; Zhan & Miller, 2003). An additional merit is that these data focus on non-fatal injuries, which make up the largest proportion of injury incidence (Horton, 2012; Wadman, Muelleman, Coto & Kellermann, 2003), as opposed to fatal injuries that are proportionally over-researched. Consequently, they have been used extensively in the United States and several other countries, including Australia (Finch, Valuri, & Ozanne-Smith, 1998), New Zealand (Langley, McNoe, & Feyer, 2006), and Canada (Rhodes, Links, Streiner, Dawe, Cass & Janes, 2002) for injury research applications.

2.4.2.1 **Queensland Morbidity Data Collection**

Hospital discharge data are a key source of injury-related information for use in epidemiological studies to examine incidence and trends in injury occurrence, and to inform the development, implementation and evaluation of injury prevention programs. In Queensland, hospital discharge, or separations data are compiled in a statewide collection entitled the Queensland Hospital Admitted Patient Data Collection (QHAPDC). QHAPDC contains information that is structured using the International Classification of Diseases Tenth Version Australian Modification (ICD-10-AM), to classify medical information into coded data. Statistical classification systems, such as ICD, standardise and aggregate data to enable national and international comparison and reporting (Williamson, Feyer, Stout, Driscoll, & Usher, 2001).

2.5 *Health Classifications*

> *"A classification is a spatial, temporal, or spatio-temporal segmentation of the world. A 'classification system' is a set of boxes (metaphorical or literal) into which things can be put to then do some kind of work – bureaucratic or knowledge production."*

(Bowker, C. & Star, S., L. (2000). *Sorting Things Out: Classification and Its Consequences*. MIT Press, USA, p10)

A classification system is a system of categories or groups to which items are assigned, according to predefined inclusion and exclusion criteria. In refined data systems, these structured classification systems comprise of a multitude of prearranged subcategories, each identified by unique descriptors or codes. Classification systems are designed to enable the efficient collection, storage, and analysis of consistent and comparable data (Horan & Mallonee, 2003). Classification systems make the coded data accessible for a multitude of purposes, and reduce the costs of collecting, integrating and using such data sources.

Bowker and Star (2000) describe a classification as desirably possessing the properties of being consistent, with unique classificatory principles, having categories that are mutually exclusive, and being a system that is complete. In other words, a classification should be an organised, structured system, enabling assignment of items to only one category at a time whilst providing total coverage of the domain that it describes. There is now a large range of classification systems employed in the various healthcare sectors internationally to capture and describe a wide range of aspects, including health status, risk factors, workforce, services, expenditure, research and development.

The first documented health classification was developed by Graunt in 1662, entitled 'Natural and Political Observations made upon the Bills of Mortality'. This work, published in London, is the first known use of standard categories to classify death information (International, 1973). Classifications continued to be developed and expanded, with Carolus Linnaeus developing in the 18th Century, the seminal

Linnaean Taxonomy for biological classification. His system divides the biological world into three kingdoms (animal, plant and mineral), with each kingdom consisting of the taxonomic groups of classes, species and genera. Following this, he developed a similarly structured classification for diseases, 'Genera Morborum', which was published in 1763 (Aalseth, 2006). Concurrently, Francios Boissier de Lacroix developed another disease classification, 'Nosologica Methodica' (Coiera, 2003), containing a total of approximately 2,400 different categories across 10 disease classes (Kornai & Stone, 2005). This latter system was considered to be unwieldy, and thus William Cullen proposed a simplified classification containing just 151 categories across four disease classes (Kornai & Stone, 2005). This classification, 'Synopsis Nosologiae Methodicae' was published in 1785.

Subsequently, there was little development in the area until the 1830's when William Farr worked on improving the classification developed by Cullen. Several refinements were made to Farr's classification across the subsequent two decades, and in 1885 the first system to give recognition of the importance of external causes of injuries, in terms of the physical and chemical forces resulting in "violent deaths or diseases", was developed (Harrison, 2000). Farr denoted such conditions as one of only five major disease categories. Harrison (2000) describes the three causal factors pertinent to injury prevention that were captured under Farr's system as "human agency", "mode in which death is produced", and "circumstances in which fatal accidents occur", all of which were captured within a single section with no distinction between the nature of injury (i.e. the resulting damage) and the external cause of the injury (i.e. cause and circumstances of the injury event). The intertwining of these two aspects of injury results in incomplete and inconsistent collection of the nature and external cause of injuries, with collection of one aspect of the injury constraining or obscuring coding of the other.

A committee, chaired by Dr Jacques Bertillon, was established in 1891 by the International Statistics Institute. It was the remit of this group to further develop an international classification system for capturing causes of death. In 1893, Bertillon published 'Nomenclatures de Maladies', which contained in it Chapter XIII, 'Affections produite par des causes extérieures' This chapter detailed the symptoms produced by external causes, and contained 24 codes relating to injury. Notably, a large focus of the chapter was on suicide, with 9 out of 24 total codes relating to this matter. Subsequent to the adoption of this classification system by the United States of America, the Public Health Association recommended that the system be routinely revised on a 10-yearly basis to maintain currency of the classification system to contemporary circumstances (World Health Organisation, 2005). Bertillon's classification became known as the International List of the Causes of Death, the first version of the ICD system that is in use internationally today.

2.5.1 ICD History

The International Statistical Classification of Diseases and Related Health Problems (ICD) is published by the World Health Organisation (WHO), and maintained by the WHO Collaborating Centres for the Family of International Classifications (WHO-FIC). The introduction to the ICD defines classification of diseases as: "a system of categories to which morbid entities are assigned according to established criteria." (World Health Organization, 1994) Vol 2, Ch 1)

The external cause of injury chapter enables the classification of environmental events, and other circumstances that cause injuries, poisonings and other adverse events. This classification system assigns codes to record causal circumstances of certain injury events, and enables additional details to be captured concerning the place of occurrence of the injury (e.g. school, workplace); the activity undertaken at the time of injury (e.g. working for income, playing sport); any objects involved in the incident; and the role of the injured party (National Centre for Classification in Health, 2002). ICD is used to translate textual information from medical records into alpha/numeric codes for storage, retrieval and analysis (World Health Organization, 1994). The Tenth Version of ICD (ICD-10) is the major system in use worldwide for morbidity data coding (Walker & McEvoy, 2004). In Australia, it is the only system in use for coding records of hospital admitted patients with regards to the causes of their injuries, and Australia uses a clinical modification of the international classification, ICD-10-AM (World Health Organisation, 1992).

2.5.1.1 ICD External Cause of Injury

As discussed previously, in the late 1800s the Bertillon list was developed. This came to be known as the International Classification of Diseases, Version One (ICD-1). The system adopted was similar to that of one developed by Farr (Langmuir, 1976; Susser & Adelstein, 1987), with all injuries and external causes being captured in a single chapter. This method of coding injury details remained in place to ICD Version Five (ICD-5), with only revisions of the code content being undertaken during this time.

The sixth version of ICD (ICD-6) released in 1948, introduced important changes to the structure and nature for classification of injuries. At this time the classification was extended to include non-fatal injury, and 'Nature of injury' and 'External cause of injury' details were separated into distinct concepts, enabling collection of both aspects separately. The separation of these two dimensions into two separate chapters has persisted through four revisions, to the current Tenth Edition of the classification (ICD-10). Changes made to the system subsequent to the major reformation of ICD-6 have largely focussed around amending individual codes and code blocks to more accurately and distinctly capture certain injuries. Effectively, there has been very little structural revision to the classification of external causes of injury within the ICD system over the last 60 years.

The most significant changes to the External Cause of Injuries chapter (ICD Chapter 20) that have occurred since ICD-6 were during the introduction of the Tenth Version of ICD (ICD-10), in 1992. A number of changes were introduced, namely:

- Change of chapter name from “Supplementary classification of external causes of injury and poisoning” to “External Causes of Morbidity and Mortality”;
- A change from a purely numeric code system (e.g. E800-E999) to an alphanumeric system (V1-99,W1-99, X1-99 & Y1-99) to enable a large expansion in the number of codes available for use, and thereby a potential increase in precision of the coded information;
- Increased range of Place of Occurrence codes and a wider range of external cause codes to which they should be assigned;
- Introduction of Activity codes;
- Transport accident codes restructured to be focussed around the role of the injured person (i.e. pedestrian, motorcycle rider, motor vehicle occupant etc.), rather than of the vehicle involved (Kreisfeld, Newson, & Harrison, 2004; Anderson, Minino, Hoyert, & Rosenberg, 2001; Griffiths & Rooney, 2003; Rooney & Smith, 2000; Statistics Canada, 2005).

As suggested by the use of the term “Supplementary” in the chapter name, until the change with ICD-10, assignment of external cause of injury codes was optional. With the introduction of this version of ICD the use of external cause codes to accompany injury diagnosis codes was made mandatory.

The central purpose of external cause of injury coding is to summarise information from medical records, to guide injury prevention activities. Injury prevention is a data driven enterprise, requiring accurate and specific information regarding the causes and circumstances of injuries to enable identification of risk factors and causes of injury, and to guide design of effective interventions. However, a statistical classification, such as ICD “must encompass the entire range of morbid conditions within a manageable number of categories” (World Health Organization (WHO), 1994, Vol 2, Ch 1). It is not meant to, nor is it able, to capture specific information on each and every nuance of an injury, but rather to be a useful epidemiological tool. It has been noted that meaningful and reliable classification of injury event information is an essential prerequisite for injury prevention (Scott et al., 2006), thus, the structure and content of the classification in usage is of vital significance to its achievement of this purpose. However, effective functioning as an epidemiological tool is also dependent upon all persons involved in the recording of information (coded or narrative) being aware of how that information needs to be documented and coded to meet ICD requirements.

2.5.1.2 **ICD-10-AM Introduction & Code Structure**

The World Health Organisation released the 10th revision of ICD (ICD-10) in 1992. A clinical modification of the classification (ICD-10-AM) was designed and implemented for use in morbidity coding within the Australian healthcare setting from July, 1998. The Australian Modification (ICD-10-AM) has been produced to include terms and elements specific to the Australian community, to enable more comprehensive capture of country specific conditions and factors. Code maps have been developed to enable backward mapping from ICD-10-AM to the international ICD-10 to enable cross comparison. ICD-10-AM is the standard system used for the classification of diagnoses and procedures in all Australian hospitals (National Centre for Classification in Health, 2004).

ICD-10-AM consists of five volumes, comprising:

- a tabular list of diseases and accompanying index;
- a tabular list and index of procedures;
- Australian Coding Standards for the selection of codes.

Within the ICD-10-AM, two chapters contain a specific focus on injury. The physical nature of the injury is coded using the Injury, Poisoning and Certain Other Consequences of External Causes chapter (Chapter XIX), and information regarding the circumstances surrounding an injury event are recorded under Chapter XX (External Causes of Morbidity and Mortality Chapter).

ICD-10-AM is a hierarchical classification system, and can be pictured as an upside-down branching tree. (**Figure 5**) Each Chapter of the code system is divided into blocks of code ranges for related conditions/elements. This system is capable of classifying injury causes at up to three levels of granularity:

- Intent (Accident, Self-Harm, Assault, Undetermined);
- Mechanism (e.g. penetrating injury, fall etc.); and
- Detail (e.g. penetrating injury due to assault by partner, fall from chair etc.). 'Detail' codes include 4th and 5th characters of external cause codes, which identify specific circumstances of the injury. Not all injury mechanisms have code descriptors available to the 'detail' level; however it is these "complete" codes that contain very specific details that are most useful for injury prevention research.

The highest or primary level of classification is the Intent of the injury (Accident, Intentional Self Harm, Assault, Undetermined Intent, Legal Interventions and Operations of War, Complication of Surgical and Medical Care). Information regarding the intent, mechanism and any object involved in the injury is all incorporated into a single code. With the highest level of grouping being the intent level, this must first be gleaned before any other aspect of injury can be coded. Consequently, the codes available to capture the mechanism and other specific details of an injury event are contingent upon the injury intent group that has been selected.

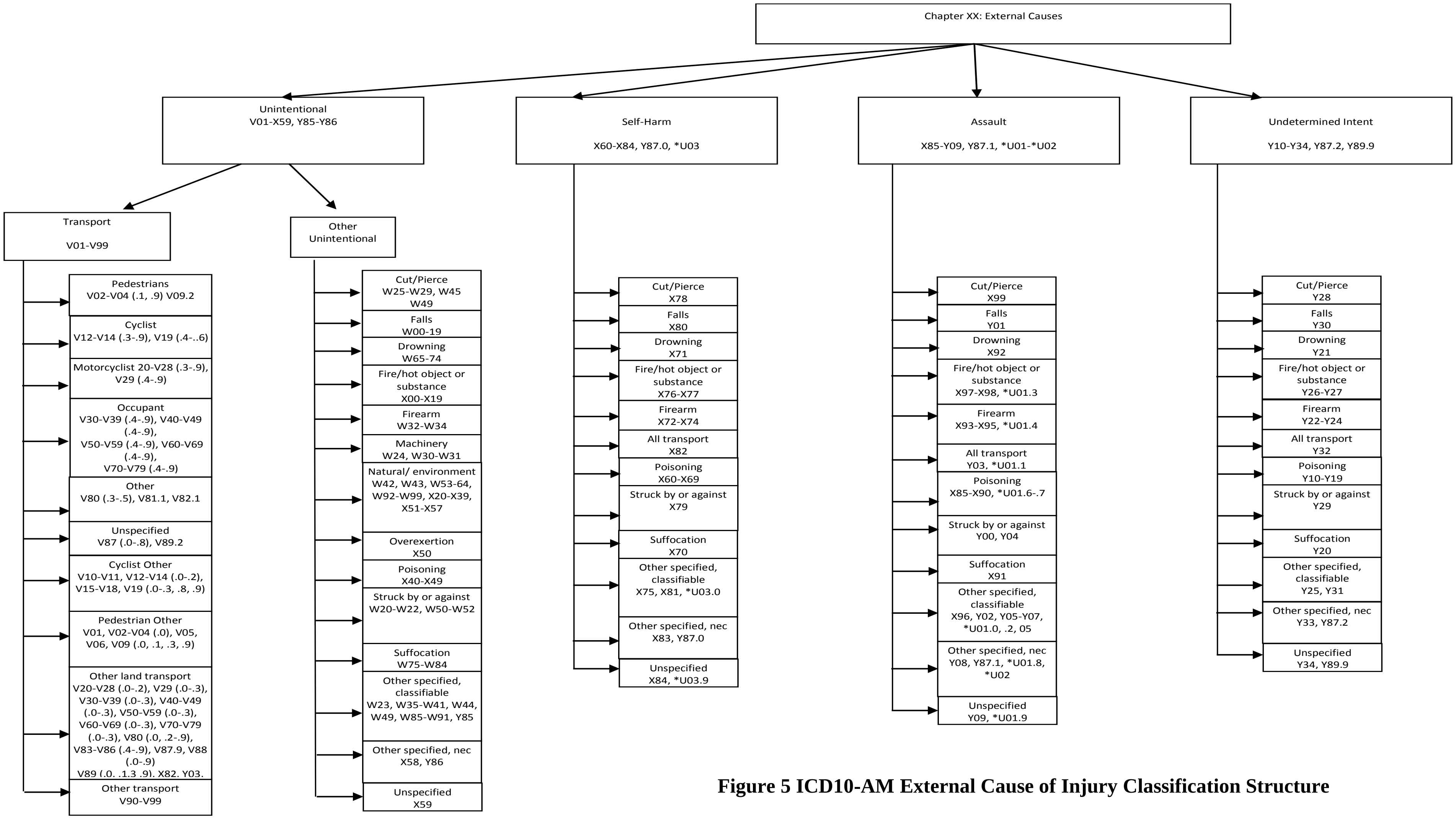

Figure 5 ICD10-AM External Cause of Injury Classification Structure

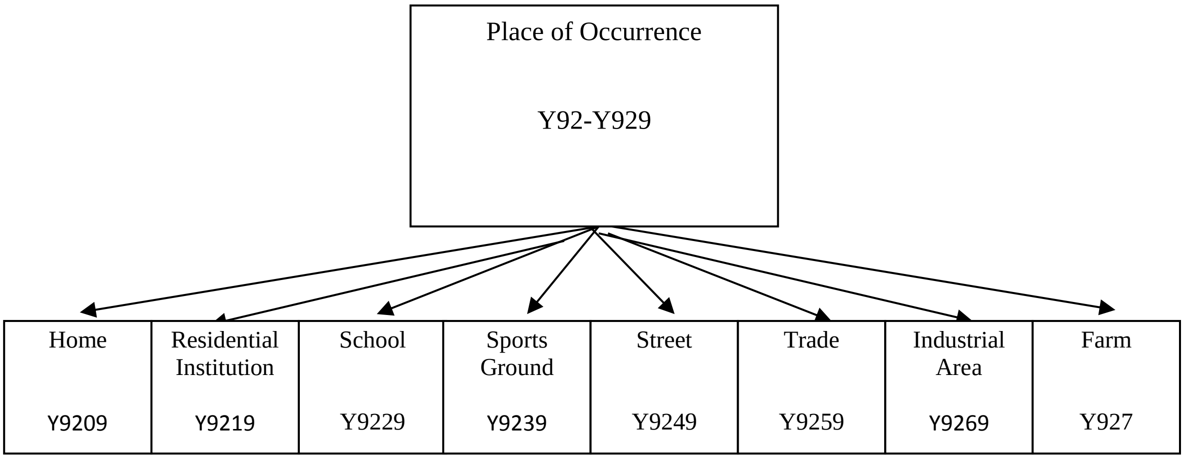

Figure 6 ICD10-AM Place of Occurrence Codes

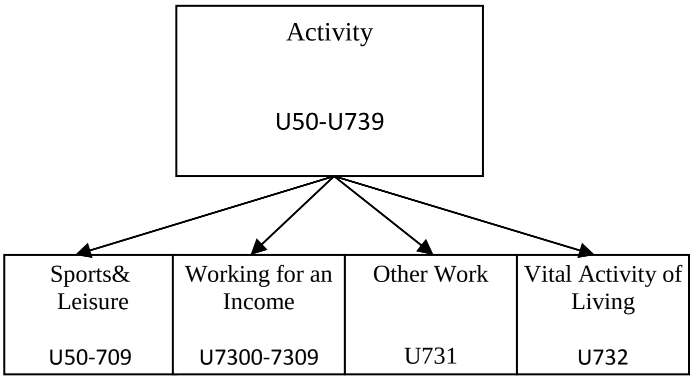

Figure 7 ICD10-AM Activity Codes

Separate additional codes are available to record information about the place of occurrence and activity at time of injury, factors that are vital to the planning of effective injury prevention programs (Katcher et al., 1999). The first set of additional codes, Place of Occurrence codes, record the broad category of geographical location the person was at when injured (e.g. private residence, school area, etc.) (**Figure 6**). The second set, Activity codes (U50 to U73), are used to record broad categories of information regarding the physical activity the person was involved in at the time they were injured (e.g. activities related to working for an income, sporting activities, etc.) **(Figure 7**).

According to McKenzie, Enraght-Moony, Walker, McClure, and Harrison (2009), the external cause of injury code chapter (Chapter 20) is the largest of all chapters in ICD-10-AM, spanning four alpha- characters (V through Y) and occupying 372 code categories out of a potential 400 available. Codes can be up to five characters in length, with the first character being alphabetic, and remaining two to four characters numeric. In ICD-10-AM, the third and fourth digits are separated with a decimal point (e.g. V12.20). The three character codes, containing Intent and Mechanism information, are the principal code level used and are the basis for international reporting and comparison (e.g. V20 Motorcycle rider injured in collision with pedestrian or animal). Additional character use (fourth & fifth digits as in ICD-10-AM) is optional, but enables extra detail to be captured regarding specific aspects of the injury cause (e.g. V20.11 Motorcycle rider injured in collision with pedestrian or animal, passenger, non-traffic accident, motorcycle designed primarily for on-road use).

In addition to the detailed three-, four- and five- digit codes that provide precise information regarding an external cause of injury, there are also some very non-specific broad codes available. The most commonplace are “Other” and “Unspecified” codes which are denoted by a .8 or .9 code suffix. “Unspecified” codes are used when there is insufficient information in the medical record to discern more detailed information for assignment of a more specific code. “Other Specified” code descriptors are applied where there is specific, and pertinent, information in the medical record regarding the aspect being coded, but there is not a code available in the code system to accurately represent this. All Intent, Activity and Place of Occurrence code blocks contain ‘Other’ and ‘Unspecified’ code options. In addition, though fewer in numbers, an assortment Not Otherwise Specified (NOS) codes and Not Elsewhere Classified (NEC) codes are also included on the code system (i.e. not using the .8 or .9 suffix). The array of non-specific codes are included to ensure that all cases can be captured by the code system, albeit with potentially limited information value.

Codes are assigned by designated clinical coders who convert textual information from medical records into the coded representations. This coding is performed according to a prescriptive series of coding rules, designed to provide guidance as to how codes should be sourced and assigned. Standardised coding rules are followed to ensure uniformity and comparability of the data (Walker & McEvoy, 2004), thereby reducing the complexity of analysing diverse qualitative information. An example of such a rule is the requirement of ICD-10-AM to give code precedence to the initial precipitating event in cases where several mechanisms have led to an injury (i.e. 'chain-of-event' injury). For example, in the case of a motor vehicle crash where a vehicle leaves the road and becomes submerged in a body of water, leading to the near-drowning of the driver, the record would be coded to a transport-related code, rather than a submersion code. Additional guidance is provided through sets of inclusion terms (terms that can be included under a particular code category, e.g. synonyms or conceptually similar terms) and exclusion terms (terms that must be coded under alternative code categories).

2.5.1.3 **ICD-9 & -10 Limitations for Injury Research**

In theory, classifying the circumstances leading to injury external cause codes should provide the information needed for injury prevention activities (Langlois, Buechner, O'Connor, Nacar, & Smith, 1995). However, a recurrent theme in the literature is that ICD external cause codes do not provide an adequate basis for contemporary injury research and surveillance (Harrison, 2000). There have been a number of significant issues identified as reducing the utility of this tool (Driscoll et al., 2004).

Whilst Australia has been pro-active to adopt, modify, and develop the ICD-10- code system, not all countries have followed suit. Most notably, the USA still uses the previous version of the ICD classification system (ICD-9) due to the need for extensive information technology infrastructure changes required to accommodate the altered structure of the Tenth Edition of the ICD code system. Many important modifications involving the coding of external causes of injury are associated with ICD-10, and for Australia ICD-10-AM. Thus, care must be taken when interpreting available literature regarding the utility of ICD for injury research as the majority of these studies were performed on ICD-9 coded data.

2.5.1.3.1 Precedence of Intent

Criticisms have been made of the method used in ICD of coding intent over mechanism, and thereby capturing both elements under the one code (Rivara, Cummings, & Koepsell, 2009). Intent can be difficult to determine for many cases, and this approach can have the unintended effect of hiding the significance of some mechanisms of injury by splitting the same mechanism across multiple intent categories (Langley & Chalmers, 1999). Additionally, the range and number of codes available to characterise an injury event is constrained by the intent category within which the event is determined to belong; some intent blocks have a great deal more codes available within compared to other intent categories.

2.5.1.3.2 Lack of Specific Detail

Two aspects of the ICD that have been criticised are its reliance upon detailed documentation to enable precise code assignment, and the unavailability of codes to accurately classify some elements (Pless & Hagel, 2005). It has been asserted that the classification lacks both the scope and level of specific detail required to design effective injury prevention and control activities (Shin, Suh, Rhee, Sung, & Kim, 2004; Schnitzer & Ewigman, 2005). Criticisms of ICD-9, and earlier versions of the ICD coding system, have attributed this incomplete coverage to the rigid structure employed that provides insufficient detail to identify certain important injury factors within hospital data (Pointer, Harrison, & Bradley, 2003).

Notably, the situation with regards to completeness of external cause coding in medical records has been reported to be of particular concern for morbidity data (Horan & Mallonee, 2003). The main limitation of the data is a lack in the precision of the detail code (Schnitzer & Ewigman, 2005), the part of the external cause code after the decimal place which identifies specific circumstances of the injury (LeMier, Cummings, & West, 2001; Schwartz, Nightingale, Boisoneau, & Jacobs, 1995). A study in Washington, employing a detailed medical record review to examine ICD-9 external cause code quality, found that computerised discharge data lacked sufficient precision to provide detailed information in a number of areas (LeMier et al., 2001). The data was so deficient that the authors noted, "researchers who require injury data at the complete E [external cause] code level should consider sources other than hospital discharge data. At a minimum, researchers must exercise caution in interpreting and using detail codes" (LeMier et al., 2001, p.337). Three key mechanisms for which data was found to be lacking were the circumstances of falls, the drugs involved in poisoning incidents, and the types of firearms involved in firearm-related injuries. Falls are a group of particular importance, given that they are a high frequency mechanism associated with injuries. This insufficiency of specific information regarding the cause of falls was also evidenced in a study of national health statistics for the USA (Fingerhut & Warner, 1997).

2.5.1.3.3 Reliance on Residual or 'Dump' Code Categories

Associated with the criticism of the lack of specific detail provided by the ICD-10-AM code system is the criticism of ICD's use of 'dump' codes. ICD is built for statistical purposes, for aggregation and reporting of large volumes of data. For completeness of capture and reporting, the code system needs to be broad enough to enable a code to be assigned to each and every case. This is done through the use of "Other Specified" and "Unspecified" codes. These two types of codes are used to capture cases where there are no other more specific codes to which they could be assigned, due to a lack of availability of more specific codes or a lack of detailed information in the source documentation. These codes are referred to as 'Residual' or 'Dump' codes. The presence of these residual codes increases the statistical sensitivity of the classification system.

Whilst it is desirable for a classification system to be able to capture all relevant pieces of information, this high sensitivity comes at the cost of specificity (Geraci, Ashton, Kuykendall, Johnson, & Wu, 1997). The assignment of these codes is associated with a loss of meaning from the coded data. The availability of imprecise "Other Specified" and "Unspecified" codes can result in a proneness to lumping of cases into these "catch all" categories. However, in order for injury prevention and control organisations to identify and implement mechanisms to effectively reduce injury events, it is vital that accurate and very specific information regarding the circumstances of injury events be readily accessible (Langley & Chalmers, 1999). These imprecise codes lack the level of detail essential for risk identification and development of targeted interventions, and therefore reduce the research utility of data collections such as hospital morbidity data (Iezzoni, 1997; Jollis et al., 1993; MacIntyre, Ackland, Chandraraj, & Pilla, 1997).

One benefit of the presence of these two categories of non-specific, residual, codes is that they can be used to provide indication from where the imprecision in data is arising. Coding rules for the ICD determine that "Other Specified" codes be used when there is a lack of a more precise code within the classification system. By comparison, "Unspecified" codes are employed when the medical documentation does not provide sufficient detail to enable assignment of a more specific code. Thus, analysis of the frequency of the use of "Other Specified" versus "Unspecified" codes can provide guidance as to whether poor data quality is a result of inadequacies of the classification system or a lack of specific medical documentation. However, there are some codes available that contain both "Other and Unspecified" cases. In these cases the codes provide very little useful information as it is not even possible to discern whether the lack of specificity is due to insufficient information in the medical record or the unavailability of an appropriate code within the code system.

In an effective injury information system, it is important to minimise the use of these residual codes, as they equate to 'lost' information. It is vital that any such data system identify and respond to the use of these codes – researching new code requirements in cases of high "Other Specified" code usage, and addressing evident documentation issues in the case of high "Unspecified" code assignment.

2.5.1.3.4 Inadequate Place of Occurrence and Activity Coding

Two other key areas found to contain very poor data quality are those of the 'Place of Occurrence' and 'Activity at Time of an Injury'. Compliance with collection/coding of these pieces of information is very low. A study of Emergency Department records found that even the general location of injury (e.g. home, school, roadway etc.) was only noted for 27% of cases (Brenner, Scheidt, & Rossi, 2002). Researchers in New Zealand identified a lack of available codes to comprehensively describe place of occurrence and nature of activity for all injury events as being responsible for poor data regarding these elements (Langley & Chalmers, 1999; Stephenson, Langley, & Trotter, 2005). Nordic researchers (Frimodt-Moller & Bay-Nielsen, 1992) further attest to the sparseness of these segments of the external cause code system, noting that even where present the codes are deemed too crude to be useful in injury prevention.

Despite their importance to injury research, the quality of place of occurrence and activity at time of injury data has failed to receive much attention in the literature. This is in part due to the fact that Activity codes were only introduced, and Place of Occurrence codes dramatically revised, for the Tenth Edition of the ICD (Langley &

Chalmers, 1999). As America is yet to adopt ICD-10 coding for morbidity, there is a general shortage of research regarding this edition of the classification system.

2.5.1.3.5 Inability to Represent Chain-of-Event Injuries

Coding rules requiring the determination of a single cause of injury are problematic for cases of injury when a chain of events, or multiple mechanisms, has led to the injury. When the initial event leading to the injury takes precedence over any subsequent events, the true cause of injury is often obscured. A study from New Zealand (Smith & Langley, 1998) found 17.7% under-reporting of drowning deaths when determined by external cause of injury code reporting compared to record review. An example in the report of missed drowning deaths involved cases where motor vehicles left a roadway and became submerged in a body of water, and the case received a motor vehicle crash code rather than a submersion code.

2.5.1.3.6 Inconsistency in System Structure

Additionally, there is inconsistency in the structure of the classification. Codes for some mechanisms (such as drowning) are split across multiple intent categories (Unintentional, Intentional, Self-Harm & Undetermined), with differing numbers of code options and detail available depending on the intent to which the injury is being coded. Conversely, some other intent categories are overly general, containing multiple disparate mechanisms within the one code block (e.g. “Other Specified” code blocks) and providing a single or very limited number of codes options to describe a particular injury event. Both scenarios can make complete and specific case selection for analysis difficult.

2.5.1.4 **ICD-10-AM Evaluation Studies**

As stated previously, there is only a limited number of published studies available that have examined the accuracy of coded external cause of injury data. The majority of studies are either dated or have been conducted in USA, and therefore under ICD-9 (Langlois et al., 1995; MacIntyre et al., 1997; LeMier et al., 2001; Langley, Stephenson, Thorpe, & Davie, 2006). Whilst the Australian Modification of ICD (ICD-10-AM) has been adopted for use by a number of countries around the world (including New Zealand, Ireland, Turkey, and Slovenia) there is a particular dearth of literature regarding the quality and appropriateness of this code system for injury researchers.

A study conducted by researchers Davie, Langley, Samaranayaka, & Wetherspoon (2008) assessed the accuracy of ICD-10-AM code assignment for external cause of injury codes. The researchers selected a simple random sample of 1,800 records from New Zealand public hospital discharges for injury. The obtained patient charts were re-coded by a senior clinical coder, blinded to the original code assignments in the national hospital morbidity dataset. Agreement between the original external cause of injury codes and those assigned by the senior clinical coder was calculated. The authors found that 26% of external cause codes (V01-Y89) had errors at the first, second or third character level, whilst 22% of Place of Occurrence codes (Y92) and 29% of Activity codes (Y93) were incorrectly assigned. There was some variation evidenced across intent blocks, with Intentional Self Harm the most accurately coded (14% error rate); followed by Assaults with a 25% error rate; and Falls and "Other non-transport accidents" at a 30% error level (Davie et al., 2008). Importantly, accuracy of the assigned codes was found to be related to the documentation clarity, highlighting the impact and importance of clear and comprehensive clinical documentation on the accuracy of the resulting coded dataset.

The authors of the Davie et al. (2008) study concluded that some specific estimates of external-cause incidence may need to be treated with caution. The prevalence of coding errors identified in the sample they studied, could potentially result in misleading conclusions as to the occurrence of certain types of injury events. It is worth noting that only one aspect of code quality was assessed in this study, that of coder agreement (i.e. a measure of code assignment error). No evaluation was conducted of the availability, or lack of, specific and accurate codes to precisely and comprehensively capture case details.

This doctoral thesis was undertaken as a part of a larger study funded by an Australian Research Council (ARC) Linkage Grant. The ARC Linkage Grant study was conducted to evaluate the quality of the ICD-10-AM coded Australian hospital morbidity dataset for external cause of injury data. Under this research program, a recoding study similar to that of Davie et al (2008) was conducted. The researchers selected a random sample of 4850 patient discharges from a random sample of 50 hospitals, stratified by hospital remoteness and injury caseload, from across four states in Australia (McKenzie et al., 2009a). An expert clinical coder then conducted on-site medical record reviews of the retrieved charts. The expert coder recoded the external cause codes for the selected medical records, whilst blinded to the original codes that had been assigned. Code agreement levels were calculated at the block level, 3-, 4- and 5- character level, and complete code level.

At a broad block level (e.g., transport, fall), agreement was found between the original and audited codes in over 90% of cases for most mechanisms. However, percentage disagreement increased substantially with each increased code digit level, as to be expected given the increasing extent of information associated with the additional code digits, and by some injury mechanisms. At the 3-character level (i.e. intent and mechanism level) disagreement between codes was 26.0% and increased to 32.4% for complete external cause codes. For activity codes, the percentage of disagreement at the 3-character level was 7.3% and 32.0% for the complete activity code. Similarly, for place of occurrence codes, the percentage of disagreement at the 4-character level was 22.0%, and 24.6%; for the complete place code. The results of this study are in line with those of Davie et al (2008), suggesting that coder variation introduces a marked amount of error to the resultant dataset.

Another study of ICD-10-AM by McKenzie and McClure (2010), using the dataset collected for the ARC Linkage Grant of which this PhD thesis is a component (McKenzie et al., 2009a), examined the specific sources of code discrepancy for injury morbidity data. The most common reason for different code assignment was coders assigning the external cause to a completely different category, by intent and/or mechanism (9% of cases). Examining the two most prevalent injury mechanisms, transport events and falls, differing effects were evidenced. The main source of discrepancy for transport events was at the 3 character level, which largely represents different vehicles/counterparts (e.g. collision with motorcycle); with 20% of transport events differed in their coding at this level. Comparatively, for falls the main source of discrepancy (41.6%) was largely related to the level of specification of the cause of the fall (e.g., trip; fall from; fall on same level etc.). The level and source of these discrepancies have different implications depending on the focus of research and the researcher's purpose for using hospitalisation data for injury surveillance. The research concludes that it is not possible to monitor the effect of prevention programs, aimed at reducing risk factors, using data with this level of misclassification error in injury cause subcategories (McKenzie & McClure, 2010; Holder et al., 2001).

Analysis of Australian hospital morbidity data (593,079 injury-related hospital admissions across a one year period) examined the coding completeness of this dataset. An unacceptable level of other and unspecified code usage was found, with 11% of unintentional injuries being assigned a non-specific injury code, and 13% of assaults coded to an unspecified category. Importantly, the mechanism of injury with the highest incidence, falls, also had the highest level of nonspecific code usage (44%) (McKenzie, Harding, Walker, Harrison, Enraght-Moony & Waller, 2006). A study of New Zealand hospital morbidity data found an overall nonspecific code usage level of 7% across all mechanisms (Langley, Davie, & Simpson, 2007). The majority of these cases were unspecified falls and other and unspecified unintentional injuries.

As outlined above, there have been few studies conducted to examine ICD-10-AM external cause of injury codes, and those that are available focus on quantifying the contribution of coder error to variability within the resultant coded datasets. Whilst it is acknowledged that this evaluates only one aspect of the code system, the research already identifies issues with the consistency of coding, and therefore usability, of such data. The available studies suggest that researchers need to be aware of the reliability of the specific ICD-10-AM coded data of interest when they undertake case selection for specific causes of interest.

It should be noted again that the studies only evaluate the quality of the coded data in terms of coder assignment properties (coder agreement and nonspecific code usage levels); there is no assessment of the appropriateness of the assigned codes for injury being captured. Whilst the coders might agree on which external cause code to assign to an injury event, it does not necessarily imply that the resulting code provides specific or useful information for injury research purposes. Thus, further evaluation of the quality of ICD codes for injury needs to be conducted to extend examination of the ICD code system beyond simplistic coder agreement and evaluate the appropriateness of available codes within the code system to the purpose of injury research.

2.5.2 Factors Affecting Injury Data Quality

Studies of quality of external cause of morbidity data outline a number of key areas that impact the quality (in terms of coder agreement and completeness) of hospital morbidity data for external cause of injury. Namely, quality is affected by a number of factors including code system characteristics, rigour of the coding process, and the degree and accuracy of information contained in the source documentation.

2.5.2.1 **Code System Characteristics**

As discussed in review of literature detailed in Section 2.5.1.3 of this thesis, the structure and content of the code system used to capture and store information has a tremendous impact on the quality and utility of the resultant data. Criticisms of a lack of specific detail captured within codes, the reliance on residual or 'dump' code categories, inadequate place of occurrence and activity codes, the inability to represent chain-of-event injuries, and inconsistencies in the code system structure have all been identified as impacting on the quality of the coded dataset. The magnitude of these factors has been identified to be so marked that the potential biases introduced may make it unreliable to use ICD-coded data alone for research or prevention studies (Fingerhut, 2001).

2.5.2.2 **Coder Error**

In addition to the impact of the code systems' structure on data quality, a number of studies have identified poor coding accuracy as a source error in a dataset (LeMier et al., 2001; MacIntyre et al., 1997; Langley, Stephenson, et al., 2006). Accuracy of the coding process, the translation of textual information in the medical records to coded form, impacts data quality. Error can be introduced in the coding process due to misinterpretation of documented information, ambiguity in coding rules, and random coder errors in selecting and recording assigned codes.

A study in Victoria (Australia) evaluated the accuracy of external cause of injury data coded with ICD-9-CM, the version preceding the current ICD-10. The expert coder's review and recoding of the original medical documents resulted in an overall agreement between the original and reviewed codes of 87% for mechanism, 95% for intent, but only 66% for complete code to the detail level (LeMier et al., 2001). Studies conducted on ICD-9 coded data have found similar effects, with between 13 and 18% of records containing coding errors (MacIntyre et al., 1997; Langley, Stephenson, et al., 2006; LeMier et al., 2001).

MacIntyre et al., (1997) examined the types of errors specific to external cause code assignment, and identified three categories of error: errors of omission (i.e. missing external causes); superfluous external cause codes (i.e. unnecessary codes); and discrepant external cause codes (i.e. those where coders did not agree on code assignment as traditionally examined in recoding studies). They found that discrepant external cause codes were predominant (68% of errors identified), whilst errors of omission accounted for 21% of identified errors, and superfluous external cause codes accounted for 11%. Coder errors and inaccuracies can be addressed through educational strategies to increase coder proficiency and reliability; however evaluation of such strategies extends beyond the scope of this study.

2.5.2.3 **Source Documentation**

Regardless the coding system in use, one universal issue impacting upon the properties of coded data is the reliance on clear and detailed documentation to be able to accurately classify an injury event (Dixon, Sanderson, Elliot, Walls, Jones & Petticrew, 1998; Langlois et al., 1995; National Centre of Classification in Health, 2003; Davie, Langley, et al., 2008). This has critical implications for the quality of hospital external cause morbidity data and injury surveillance, as it has been acknowledged that hospital records are often incomplete or lacking important details of the circumstances surrounding an injury (Ewigman, Kivlahan, & Land, 1993; Katcher et al., 1999; Brenner et al., 2002; Irving, Norton, & Langley, 1994; Juda & Schwartz, 1994; Runyan, Bowling, & Bangdiwala, 1992; Schwartz et al., 1995). Within hospitals, the coding process is performed by trained Clinical Coders who work to systematically compile and translate descriptions of injury causations, medical diagnoses and procedures to standardised codes. This information is documented by clinicians in many a varied format, often using individualised notations and abbreviations. Consequently, interpretation and comparison of such incongruent data can be very complicated, and a lack of documentation sources or clear information within the records hampers these efforts.

Inaccuracies due to poor documentation can result in an information bias in the resultant data (Centers for Disease Control and Prevention, 2001), and has been shown to decrease data quality by contributing to overuse of non-specific 'dump' codes (Langlois et al., 1995; LeMier et al., 2001; Langley, Davie, & Simpson, 2007). McKenzie & McClure (2010) assert that the provision of clear information within clinical records, for use in the coding process, can minimise coding discrepancies. Whilst the clinical treatment of the patient is foremost, if effective programs are to be developed to reduce the occurrence of future injuries then the "importance of documenting circumstances of injury cannot be overemphasised" (Brenner et al., 2002, p.184).

A study of emergency department records for children being treated following bicycle-related injuries found that whilst the documentation contained detailed clinical information, however details concerning the circumstances and location of an event had a much lower completion rate (Moll, Donoghue, Alpern, Kleppel, Durbin, & Winston, 2002). In only 58% of cases was the other vehicle/object involved in the crash identified, the precipitating event was documented for 24%, and location of crash and helmet use were each available in only 23% of records. Notably, severely injured patients had significantly lower rates of documentation for location of event. Schwartz et al. (1995) compared the information recorded by clinicians in medical charts to that of dedicated research officers who were purposely recording relevant injury information during the intake interview at hospital. The researchers found that when emergency physicians compose medical records for trauma patients they lose one third of the available data about cause of injury in the process of obtaining the patient's history and a further third is lost because they do not document in writing all of the information that is verbally obtained.

Several other studies have examined the completeness of medical documentation, all of which have found deficiencies (Brenner et al., 2002; Irving et al., 1994; Juda & Schwartz, 1994; Katcher et al., 1999; Runyan et al., 1992; Schwartz et al., 1995). An unpublished report from Western Australia also concurred with regards to the particular lack of incident location information in hospital documentation (Gavin & Gillam, 2004). Furthermore, a study evaluating the level of detailed information in a variety of documents (e.g. hospital discharge, Emergency Department, Emergency Medical Services, Nurses' notes) found all sources to be lacking, with no one type of form having cause of injury information for more than 51% of cases (Langlois et al., 1995). In combination, results from these studies indicate that medical documents have such high rates of missing data across the various injury-related elements that they lack sufficient information to be effective for injury surveillance and prevention. This deficiency in external cause information points to the need to standardise forms for data collection (Brenner et al., 2002).

In essence, given the strict coding guidelines regarding the level of evidence required to assign a specific external cause of the injury code (Pless & Hagel, 2005), hospital documentation often does not adequately contain the detailed "who, what, when, where, why, and how" of an injury event required to facilitate injury research activities. One explanation for this deficiency is the reliance placed upon extracting details of an injury event from traumatised witnesses or caregivers, whose focus has been on the immediate treatment of the injury and condition of the injured person (Katcher et al., 1999). However, if this information is not able to be recorded at the time of treatment, "reconstructing the event later is difficult, even by direct interview" (Katcher et al., 1999, p.252). Therefore, it is vital that this information is gathered as soon after the incident as is practicable, and from as objective and impartial a witness as is available.

The identified importance of collecting information as soon as possible following the injury event, to maximise the accuracy and extent of recall, highlights the potential importance of ambulance records to the collection of injury data. Paramedics are placed in a unique position; they are trained observers, who often attend to patients at the scene of an injury event, and record a detailed narrative account of each case. Thus, paramedics are able to gather verbal accounts from the patient and/or witnesses at a time most proximal to the event. In addition, they are often able to witness firsthand the scene and circumstances of an injury event. This places paramedics in ideal position to gather relevant injury information, in particular with regards to environmental aspects.

McKenzie, Enraght-Moony, Harding, Walker, Waller & Chen (2008) conducted a survey study of clinical coders in Australia to elicit their opinions as to the quality of external cause codes in ICD-10-AM, and the availability of external cause of injury information in clinical records. Clinical coders are trained experts in clinical coding and classification, and as such are a valuable source of information regarding problems with, and solutions to the collection of high quality data. Clinical coders viewed missing external cause information and missing documentation as having the greatest impact on the quality of external cause coding. A lack of external cause information in medical records, and poor clinical documentation regarding injury circumstances, were the major factors impacting on the specificity and resultant quality of external cause code use. This lack of detailed information within the medical records was identified to be particularly marked with regards to place of occurrence and activity at the time of injury information. Missing external cause information and missing documentation were rated by 78% and 51% of respondents, respectively, as the factors with the greatest impact for external cause coding.

The research by McKenzie et al., (2008) confirms the need to focus on the availability and level of detail of external cause of injury information within clinical records, if improvements are to be made to hospital morbidity datasets for injury research purposes. In order to develop and improve hospital morbidity data it is critical that a focus be placed on building in quality from the bottom-up (i.e. from the point where the information is collected and recorded through the coding process and to the interpretation and analysis of the resulting data) (National Health Service, 2004). Ambulance services are the first point of medical contact for many hospitalised injured patients; approximately 30-40% of all admitted patients arrive to hospital by ambulance (Toloo, Rego, Fitzgerald, Aitken, Ting, Quinn & Enraght-Moony, 2012). The ambulance records for these patients represent a potentially rich data source to be explored for potential contribution to the collection and improvement of injury-related information.

2.5.3 ICD-10-AM Development Process

The ICD-10-AM classification is revised routinely to ensure that the codes remain current and respond to changes in modern society. Updating of the classification enables capture of emerging trends and facilitates the systems' responsiveness to users' changing needs. In Australia, the update process for ICD-10-AM is currently conducted by the National Casemix and Classification Centre (NCCC) at University of Wollongong. Previously this had been done through the National Centre for Classification in Health (NCCH). New update editions are released bi-annually, with the latest edition (ICD-10-AM – 7th Edition) being implemented in Australia in July 2010. This process of review and update is achieved through a public submission process, where interested parties can submit requested change for consideration by the managing body. The most significant changes to ICD-10-AM external causes chapter were introduced in 2002 with the release of the Third Edition of ICD-10-AM. Implemented changes involved the expansion of certain external cause code blocks and addition of extra external cause codes within these to capture more specific information; however no structural changes have been made since the introduction of ICD-10-AM.

A major revision is planned for the classification, with development already underway (i.e. ICD-11). Concerted efforts are currently underway to modernise the ICD classification for external cause of injuries and address identified problems with the current version of the code system. Recently published initial recommendations for the development of ICD-11 propose the need to introduce a more uniform and standardised code structure (McKenzie, Fingerhut, Walker, Harrison, & Harrison, 2012). The main notion for standardising the structure of the codes is to determine designated positions within the code string for placement of injury intent, mechanism and object information, to enable ease of extraction and reporting of these elements.

Given that injury prevention strategies are based upon identifying, understanding and modifying causative factors behind injury events (Demetriades et al., 1998), the method in which ICD external cause codes group and define the causative factor for injuries is highly relevant to the practice of injury surveillance and prevention (Harrison, 2000). It is apparent from the trajectory of development of the external cause of injury codes within ICD-10-AM that they have not been either developed or refined within an injury prevention framework, but rather on the basis of subjective determinations regarding gaps within the codes. If ICD is to provide comprehensive and accurate data for injury prevention, and remain in use as the principal morbidity classification system for external cause of injury, it is vital that any development of the system be grounded in injury prevention theory. The impact of such lack of theoretical foundations needs to be assessed in terms of its impact on the resultant dataset.

2.5.4 Developing an Alternative Classification - ICECI

Assessment and comparison of existing systems has led to the conclusion that it is feasible and desirable to develop an internationally coordinated classification of external causes of injury (Scott et al., 2006). Such a system should be designed to meet the needs of injury researchers and prevention practitioners; to reflect contemporary best practice for injury surveillance; and facilitate an international consensus about how external causes can be described. In response to the perceived need internationally for more detail and improved quality of injury data, the International Collaborative Effort on Injury Statistics, a multinational effort sponsored by the CDC, developed a new system for external cause coding. The new classification system, the International Classification of External Causes of Injury (ICECI), has a multi-axial, modular and hierarchical structure for classifying external causes (Horan & Mallonee, 2003). This code system has been formally recognised as a Related Classification in the World Health Organisation Family of International Classifications (WHO-FIC).

ICECI was designed to complement ICD coding of injuries, and enable more detailed recording of the circumstances of the injury event. The system has one core module which comprises seven independent coding axes (mechanism of injury, objects/substances producing injury, place of occurrence, activity when injured, the role of human intent, use of alcohol, and use of (other) psycho-active drugs). Additionally, five supplementary modules are available for coding extra details relating to special topics (violence, transport, place, sports, occupational injury) (World Health Organization, 2003). The multidimensional structure enables numerous elements to be recorded independently of one another (e.g. object independent of intent or mechanism) with code subcomponents being combined following code assignment (i.e. post-coordination). The majority of codes within the ICECI are mappable to ICD-10 codes, to enable integration of data between the two classification systems, though this is often associated with some loss of information.

This classification system was developed specifically to meet the requirements of injury prevention researchers, in response to a perceived need for more detailed information about injury circumstances than is available through the ICD classification system. The ICECI is based on an explicit model of injury occurrence - injurious events are described in terms of underlying and direct mechanisms of injury, which are mediated by objects and substances, and occur in a context that can be characterized in terms of place, activity, and other conceptual dimensions. ICECI is designed to provide a systematic description of how injuries occur. It was originally produced for settings where data was routinely collected for statistical reporting (e.g. hospital discharge data), but has also since been applied for other purposes.

The complexity of events that result in injury information provides a considerable challenge for any system aiming to be both useful and easy to use. The greater range of items and categories in the ICECI provides the potential to record more aspects of place and activity than the ICD items (for example, whether indoors or outdoors), and more specific types of places and activities (for example, stairs in an apartment that is not the injured person's own home, rather than "home"; or during cardiovascular training for field hockey, rather than "sport"), and to do so with great flexibility (that is, the numerous elements of the ICECI can be used where relevant because they are not tied together as complex codes). There is only limited evidence at present as to the precision and comprehensiveness of ICECI codes, with few published studies which focus on evaluating the practicability, validity, and reliability of this tool for use as a research instrument. The most comprehensive evaluation undertaken to-date was as part of a longitudinal study of community-based coding journal records for 563 injuries in children aged between 5 and 12 years (Scott et al., 2006). The researchers found for the sample of injuries coded, there were no event, location, or activity details which could not be coded using the ICECI. A second study, limited to concussive head injuries resulting from sport and recreation activities in school children, compared the coding of mechanism of injury using both ICECI and ICD, finding the two system to be comparable for capturing this information (Kozlowski, Leddy, Tomita, Bergen, & Willer, 2007).

The main impediment to alternate systems such as ICECI is that most info systems and reporting requirements, which have been developed around the ICD code system, rely on a pre-coordinated structure (where code subcomponents are organised into a string and are indexed by that string) to give a single multidimensional external cause of injury code. ICECI, with a post-coordinated structure, has not been stringently tested in the practice of clinical coding for routine records, nor has its suitability for statistical aggregation and normal reporting purposes been evaluated. In addition, ICECI contains only the external causes of injury, and not the injuries themselves, thereby still requiring use of ICD-10 to code the nature of injury.

2.5.4.1 **Why Further Develop ICD for External Cause?**

Whilst there are many criticisms of the structure and utility of ICD external cause of injury codes, there are still many valuable reasons to persist with their use and development. Internationally, the ICD system of classification is embedded in hospital and public health systems for morbidity and mortality coding. ICD is used in these facilities for more than just external cause of injury coding, it is employed to capture all aspects of the healthcare encounter, from the reasons for contact with health services, the nature of illness and injury to any procedures conducted in the course of the healthcare. Given that ICD-10 is already in use within Australia, would need to be maintained for nature of injury and procedure coding, and complies with existing data systems, it is rational to explore methods to enhance the current ICD-10-AM external causes of injury codes rather than investing in establishing a new and relatively untested classification. As external cause codes are not part of the funding base for hospitals, it would be difficult to effect implementation of new distinct data collection for injury, as these would likely be seen as of little utility for the individual facility and an additional workload burden.

Data collections outside of the hospital system tend to only capture specific population subgroups, or injury types. Whilst these collections can be very informative regarding the population they access, they are not representative or comprehensive enough for epidemiological purposes. Hospital morbidity collections, the majority of which in developed countries are coded using the ICD classification system, have long been recognised as potentially one the most effective and efficient means available to collect data needed to prevent and control injuries that lead to hospitalisation (McKenzie & McClure, 2010; Schoenman & Sutton, 2005; Zhan & Miller, 2003). Given that a key purpose for collecting external cause of injury information is for injury research purposes, this should make any necessary reforms to the system accessible.

Further action in this area should be focussed on improving these data collections and associated injury classification system. In order to do this there is the need to evaluate the ICD-10-AM code system in terms of its appropriateness for injury prevention data needs, and to introduce an injury prevention theoretical framework to the structure to improve its properties for this purpose.

Proposals for future developments of the ICD external cause chapter have commenced (McKenzie et al., 2012), however the timeframe for implementation of these has not yet been finalised. Hence, the current system will remain in place for many years to come. In the meantime, further analysis ICD-10-AM will generate deeper knowledge of the quality of external cause of injury codes, provide an evidence base to inform the development of ICD-11, and deliver ongoing trend analysis.

CHAPTER 3. LITERATURE REVIEW - 'QUALITY' & INJURY DATA

3.1 *Introduction*

Chapter Two provided an overview of the field of injury epidemiology, the burden of injury both locally and internationally, and the vital importance of injury prevention to reducing the occurrence and impact of injuries on society. Key public health injury prevention frameworks were discussed, with particular reference to Haddon's Matrix, a cornerstone of public health and injury prevention for four decades. Haddon's matrix employs a phased-factor approach to injury prevention by combining a cornerstone framework of epidemiology, the epidemiological triad of Host, Agent, and Environment, with a temporal factor to produce a nine-cell matrix. This matrix dissects injury events into more manageable segments to aid identification of prevention opportunities.

As discussed in the previous chapter, it is essential that reliable information regarding the circumstances of injury events be available to facilitate the identification, design and evaluation of effective prevention strategies. However, current deficiencies in hospital morbidity data and ICD-10-AM, the clinical classification system used in Australian hospitals to code external cause of injury information, were highlighted. Despite widespread criticisms of the ICD-10-AM external cause of injury code system, there is a dearth of studies evaluating the coded data beyond basic properties of coder agreement and data completeness. If injury coding, and resultant injury datasets, are to be improved for the purpose of injury research, it is critical to undertake a robust evaluation of this code system and the factors that impact upon the quality of clinical coding.

Chapter Three will discuss a novel method to evaluate the utility of ICD-10-AM codes and clinical documentation to injury research activities, and to provide an evidence-based platform for future development endeavours. This method is based upon use of the Haddon's matrix as a potential framework for systematic collection of cause-of-injury information.

3.2 *Defining Quality*

Data is processed in a variety of different and complex ways to generate information that is used as a basis for decision making. As the volume of data increases, so does the complexity of managing it and the likelihood that poor data quality will lead to flawed decisions. An assessment of data quality asks a series of routine questions; are the data what they are supposed to be; what is the quality of the data; are the data in the right context; do the data have integrity; are the data and associated metadata (information regarding the content, context and structure of data elements) accessible; and how useable are the data in their current state (Scarisbrick-Hauser, 2007).

Despite the widespread use of the term 'data quality', there is, in fact, very little agreement or standardisation as to what this term actually means, or how to measure it (Wand, 1996). A study by Wang et al (1993) identified approximately 200 words to describe data quality (e.g. accuracy, completeness, currency, correctness, relevance). At a general level, data quality is described as the state of completeness, validity, consistency, and timeliness that makes data appropriate for specific decisions (Scarisbrick-Hauser, 2007). Customarily, for health-related data, quality is often conceptualised as accuracy, relevance, timeliness, completeness, reliability, and accessibility. However, for each term there is little agreement as to the nature (i.e. are they concepts, goals or criteria?), definition and measurement of each of the constructs. Even a relatively obvious dimension, such as accuracy, does not have a well-established definition (Wand, 1996). Yet, it is critical to supporting the design of better quality to understand the meaning of 'quality' and how it is measured.

A systematic review was performed for the concept of data quality (Arts, De Keizer, & Scheffer, 2002), identifying the two most frequently used concepts: "accuracy" and "completeness" (Australian Institute of Health and Welfare, 2004; Baker et al., 1992; Berry & Harrison, 2007; Boufous & Williamson, 2003; Bright et al., 2006; Graitcer, 1992; Haddon, 1980; Harrison, 2000; Harrison & Tyson, 1993; Holder et al., 2001; Krug, 2004; Kumar, 2001; Langley & Brenner, 2004; Murray & Lopez, 1996; Robertson, 1998). Arts et al. (2002) formulated, as a result of this review, definitions for data accuracy and data completeness. These authors defined data accuracy as the extent to which registered data are in conformity to the truth (as determined by comparison to a gold standard); and completeness to be the extent to which all necessary data that could have been registered, have actually been registered. Levitin and Redman (1995) consider accuracy to be the foundation dimension of data quality; if data are not accurate the other dimensions are of little importance.

An evaluation of Britain's National Health Service (NHS) data systems commented that considerable attention has also been focused on readily measurable aspects of data quality (i.e. validity and completeness of data items), whilst harder to measure but arguably more important aspects in the context of the overall information have been neglected (National Health Service, 2004). If the quality of hospital morbidity data for external cause of injury is to be rigorously evaluated, and improved, it will be necessary to establish an appropriate framework for evaluation of injury data quality. In order to develop a suitable framework for injury data quality, it is necessary to look to data quality frameworks from other arenas.

Wand & Wang (1996) summarised the available literature around data quality, in general, to capture the most frequently cited data quality constructs. (**Table 1**) The authors summarised the retrieved terms with respect to whether each term relates to an intrinsic view of the quality of the component data elements (i.e. an internal view of quality of the data system), or an external view of the dataset (i.e. the data in application). This dichotomisation of quality extends the view from being that of purely concerning the completeness and consistency of the individual data elements, to a more encompassing perspective of the data's externalisability to its intended application.

Table 1 Data quality dimensions as related to the internal or external views

	Dimension
Internal view (design, operation)	**Data-related** accuracy, reliability, timeliness, completeness, currency, consistency, precision System-related reliability
External view (use, value)	**Data-related** timeliness, relevance, content, importance, sufficiency, usableness, usefulness, clarity, conciseness, freedom from bias, informativeness, level of detail, quantitativeness, scope, interpretability, understandibility **System-related** timeliness, flexibility, format, efficiency

(Wand & Wang, 1996)

The International Standards Organisation (ISO) develops standards and definitions for a wide range of commercial and industrial applications. Quality is defined as the totality of characteristics of a product that bear on its ability to satisfy stated and implied needs (ISO 8402, 1994). In the new ISO/DIS 9000:2000 standard (2000) the definition of quality is: "Ability of a set of inherent characteristics of a product, system or process to fulfil requirements of customers and other interested parties." In **Figure 8**, the quality of the dataset is represented as the difference between the universe of discourse (i.e. real world of interest) and the dataset. Additionally, there are two different perspectives depicted: those of the data producer and the user.

A similar definition could be applied to the context of a clinical dataset, such that data quality could be defined as “the degree to which an inherent set of characteristics fulfils requirements” (International Standards Organisation, 2005). This definition begins to introduce the concept of evaluating the data in terms of the appropriateness of the data content and structure for the purpose for which it is being employed.

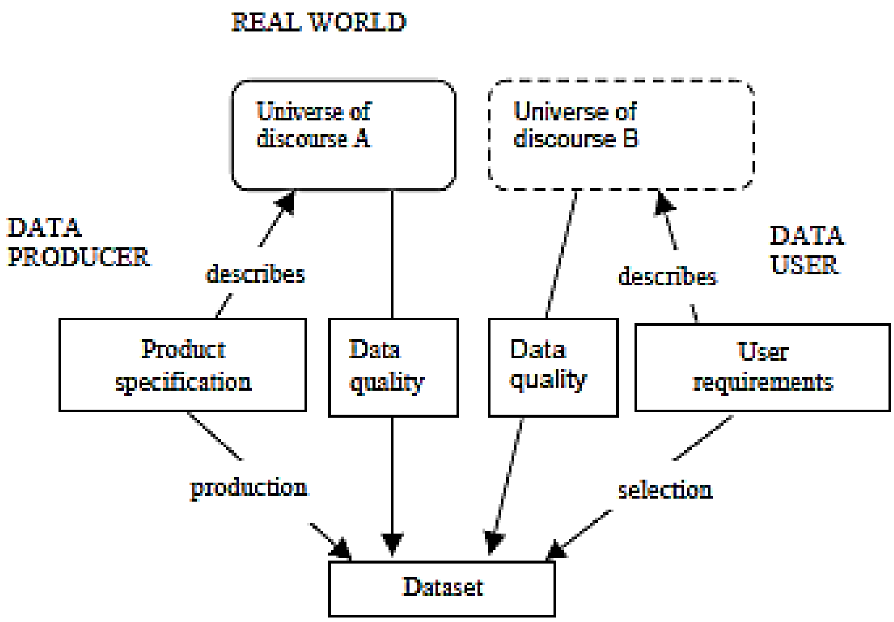

Figure 8 ISO TC211, 2001, ISO/DIS 19113 (www.iso.ch)

In line with the ISO’s practice of framing quality in terms of the application for which it is being used, the systematic literature review by Arts et al. (2002) concluded that the data requirements that proceed from the intended use of the dataset were given a pivotal position in the definition of quality. Thus, the intended use of data determines the necessary properties of the data, and thus how the 'quality' of that data is conceptualised. Despite the multitude of terms that are about to describe data quality, a common theme that emerges in the literature is that quality is an issue that needs to be assessed from the data users' perspective (Arts et al., 2002, p.602).

To-date, evaluation of ICD external cause of injury data quality reflects the reliance on accuracy and completeness identified by Arts et al (2002). A systematic literature review by McKenzie, Enraght-Moony, Waller, Walker, Harrison & McClure (2009) identified only five studies that evaluated aspects of the quality of ICD external cause of injury codes. All available studies used medical record review and recoding methodologies to evaluate accuracy of code assignment (i.e. coding error), and data completeness in terms of missing values and use of nonspecific code categories (i.e. "Other Specified and Unspecified").

Despite quality being represented as a multidimensional concept in the wider literature only a narrow operationalisation of the term has been employed in the evaluation of data quality for ICD codes. The lack of a rigorously defined set of data quality dimensions (Wand, 1996), makes the customary measurement and comparison of data quality for ICD coded external cause of injury data problematic. It is likely that this lack of consensus and methods for measurement are in part responsible for the dearth of literature regarding the quality of external cause of injury codes. Currently, there is a lack of knowledge, understanding and familiarity with the evaluation and use of hospital data for injury surveillance, and there are very few injury researchers driving a programme of quality assurance for these data.

3.2.1 Fit for purpose

The concept of "fit for use" has been widely adopted in the quality literature, and is now the single most widely accepted definition of quality (Price, 2004, p6). This conceptualisation emphasises the importance of taking a consumer viewpoint of quality, because ultimately it is the consumer who will judge whether or not a product is fit for use (Deming, 1986; Dobyns, 1991; Juran, 1980a, 1980b).

The concept of fit-for-purpose was developed in the commercial arena by Mr JM Juran, a systems and management quality expert. He conceptualised data quality in terms of, "Data are of high quality if they are fit for their intended uses in operations, decision making and planning" (Juran, 1980a, 1980b). This definition of quality contextualises the data and clearly expresses the notion of data or information quality being dependent upon the actual use of the data (Wand, 1996). Data that are of high quality or utility for one application may not be of the same high quality in the context of a different application.

3.2.2 Data Quality Vs Information Quality

'Data Quality' is a term that has often been used in the past interchangeably with information quality, but it is actually a more limited term. Data quality refers to the building blocks of information i.e. data items. "Data" may be in many forms (e.g. facts, readings and measurements); however the items in isolation are essentially 'meaningless'. Data is merely a raw sequence of symbols or representations; it is not until the data are assembled, contextualised and interpreted that they become information (National Health Service, 2004).

Conversely, information is data that has been interpreted, given context, or to which commentary has been added by a user for a purpose, giving it 'value' (National

Health Service, 2004). Information quality concerns the application of data to end-user needs, and adopts the general definition of quality from manufacturing, that of "fitness for purpose" (Juran, 1992). Quality information meets certain recognized criteria such as "accuracy", "timeliness", "relevance", and "understandability", however the meaning of information quality lies in how the information is perceived and used by its 'customer'.

A study by Light et al (2004) examined data quality in the context of classroom teaching. These researchers commented that, "Data exist in a raw state. They do not have meaning in and of itself, and therefore, can exist in any form, usable or not. Whether or not data become information depends on the understanding of the person looking at the data" (Light, 2004, p.3). The translation from data to information can be considered on a continuum, with the level and nature of information communicated by a data element being dependent on user needs and the context in which it is being applied.

Price and Shanks (2004) provide a product- and service-based model of data and information quality, with data seen as a commodity and information as a quality ascribed by the consumer. In their explanation, the product-based perspective (also called data quality) includes the commonly used criteria of completeness and accuracy. Their complementary condition, the service-based perspective of quality (commonly called information quality), involves the use and delivery of data. Criteria for measuring the service-based perspective include timeliness, relevance, and accessibility as judged by the information consumers.

A fit-for-purpose view of quality in its essence contains two interrelated aspects: a) the characteristics that meet user needs and thereby provide user satisfaction; and b) the absence of deficiencies that result in user dissatisfaction (National Health

Service, 2004). Developing a model for information quality involves two stages: first, highlighting which attributes are important and second, determining how these attributes affect the customers in question. The next challenge is to operationalise the resulting model for a particular application. The case examined here-in is the use of external cause of injury data for injury prevention research.

There are a number of sources for poor information quality, such as errors in systems design, the way the information is processed or the way it is interpreted (National Health Service, 2004). Data quality is an important component of information quality but there are other components that influence just how useful the information is to a particular user Poor data quality has the capacity to constrain the quality of any information derived from that data; therefore data quality can be considered a key component of information quality. However, data quality alone neglects important elements of overall information quality (e.g. just how useful information is to users) (National Health Service, 2004). Whilst the absolute attributes of data are important, it is how those attributes are perceived that defines the information quality.

3.3 *Improving Hospital Morbidity Data for Injury Research*

Injuries are a significant cause of morbidity and present a heavy burden on the community economically and socially. Injury surveillance, gathered for the purpose of identification of risk factors and design of injury prevention strategies, is dependent on accurate and comprehensive data. There is a recognised need internationally for improved data collection for injury prevention activities (Garrison et al., 1997; U. S. Department of Health and Human Services, 1990; U. S. National Highway Transport Safety Administration, 1996) The Australian National Injury Prevention and Safety Promotion Plan 2005 (National Public Health Partnership, 2005) identified the quality of, and access to data and injury information as a current impediment to injury prevention activities. Hospital morbidity data, which is a vital information source for injury prevention research in Australia, has been criticised as lacking quality and precision, with the onus being placed on governments to enhance injury data collections and enable access to quality data and its analysis for injury prevention (Commonwealth Department of Health and Aged Care, 2001; Strategic Injury Prevention Partnership, 2004).

The central purpose of external cause of injury coding in hospital records is to summarise information from clinical documentation, to guide injury prevention activities. According to the Australian Institute of Health and Welfare, external cause of injury coding, "enables categorisation of injury and poisoning according to factors important for injury control. This information is necessary for defining and monitoring injury control targets, injury costing and identifying cases for in-depth research. It is also used as a quality of care indicator of adverse patient outcomes" (Australian Institute of Health & Welfare, 2013b). External causes of injury codes are not used by hospitals for funding purposes; given the crucial role of ICD diagnostic and procedure codes in determining hospital funding, these codes have been well validated. However, the same cannot be said about the external cause of injury codes (Boufous & Finch, 2006). It is likely due to the lack of funding implications for hospitals that injury data has received little attention within hospital morbidity collections in terms of quality evaluation and assurance.

A sensible response to the asserted weaknesses of hospital morbidity is to firstly benchmark their quality for injury research, and evaluate means by which to enhance and develop this extant data source as a tool for injury research. This is particularly pertinent given that the use of hospital discharge data is increasing in prominence for shaping national injury prevention policy and practice (Langley, Davie, & Simpson, 2007). Accurate and comprehensive data pertaining to the circumstances surrounding injury events (e.g. the external causes of morbidity) is fundamental to enable development of effective strategies to mitigate the impact of injuries (Langley & Chalmers, 1999). A solid evidence base is essential for the development of effective interventions (Wright & Edgerton, 2003). Thus, research is required to ensure that data collections regarding injury causation are effective for aetiological research and injury prevention activities.

The research introduced in Chapter 2 of this thesis identifies two key areas that impact upon the quality of hospital morbidity injury data: 1) characteristics of the clinical classification system and coding process; and 2) availability of information in the clinical documentation. Thus, to improve the quality of injury-related hospital morbidity data for injury prevention, two main areas on which to focus resources are: 1) the development of external cause of injury codes to suit the purpose of injury prevention research; and 2) the provision of more detailed documentation from clinicians.

3.3.1 Sensitivity and Specificity

In order to accurately evaluate the appropriateness of ICD-10-AM external cause of injury codes for injury prevention research, it is vital to have a framework by which to assess the 'fit-for-purpose', or information quality. The nature and structure of the classification system used for external cause of injury coding will have a notable impact upon the quality and utility of the resultant administrative dataset for the purpose of injury research (Gillam, 2004; Harrison, 2000). Two key properties of a classification system are sensitivity and specificity. Sensitivity is the proportion of actual positives which are correctly identified (e.g. the proportion of fall-related injuries that are coded in ICD-10-AM as a Fall [W00-W19]). Specificity is the proportion of negatives that are correctly identified (e.g. the proportion of cases non-fall related injuries that are coded to a code range other than fall [W00–W19] in ICD-10-AM). Whilst displaying high statistical sensitivity, to ensure complete capture of cases, the classification system in use must balance this with an acceptable level of specificity, to satisfy the requirements of the end-user. Arguably, a system could achieve 100% sensitivity by coding all cases to an element (e.g. coding all injury cases to W00–W19), but this involves a trade-off against specificity. In the given example, specificity would be very low due to the inclusion of many non-fall cases within the this falls code range, and the data within this category would be rendered useless to injury researchers. Thus, a quality data system must display both high sensitivity and specificity.

3.3.2 Haddon's Matrix: A Theoretical Framework for Injury Data

ICD external cause of injury codes undergo routine review and development, with the introduction of ICD-10 seeing substantial changes to how the code system was structured, and the content of many codes. This International code system has subsequently been modified within Australia to meet Australian requirements (ICD-10-AM). However, there is no evidence of these developments having been based in injury prevention theory, despite the key purpose of the External Causes of Morbidity and Mortality chapter in ICD (Chapter XX) being for injury prevention research purposes It appears that external cause codes have been developed using the same process of code development (i.e. primary input by classification specialists as opposed to content specialists) as other sections of ICD, such as diagnosis and procedure codes. Evaluation of the external cause of injuries chapter, and whether it meets its intended uses, should be measured in the context of its use, namely for injury prevention. Such an evaluation would provide an evidence base by which to quantify the information quality (fit-for-purpose) of both injury documentation and ICD-10-AM external cause of injury codes, and provide an evidence-based platform for classification development efforts.

As discussed in Section 2.5.1.4 of this document, studies of ICD data quality have traditionally focussed on either the proportion of nonspecific "Other and Unspecified" codes present within a dataset, or on the level of error in code assignment (appraised via recoding studies). High proportions of cases being assigned an Other Specified code (particularly when there are few cases being assigned an Unspecified code) represent an area of potential classification development, where new codes could be developed to capture the cases ‘lost’ to this category. High proportions of cases being assigned an Unspecified code (particularly when there are few cases being assigned an Other Specified code) suggest an area where there is insufficient clinical documentation to assign more specific codes. However, this system of evaluation lacks refinement, with the measurement of a code’s degree of “specification” (Defined/Undefined) being too granular to be truly informative.

ICD-10-AM external causes of injury codes are multifactorial, pre-coordinated codes that may contain multiple elements within the one code ID. For example, W09.9 (‘Fall involving unspecified playground equipment’), under the ‘traditional’ Defined/Undefined method of evaluating code quality would be classified as ‘Undefined’ (due to the .9 terminal digit & wording “unspecified playground equipment”). Whilst this code is “Undefined” for one aspect (i.e., the exact nature of the playground equipment), this does not in reality mean it contains no useful information for injury prevention research. The code W09.9 conveys the mechanism of the injury (i.e. fall), and thereby, implicitly, the energy source (fall = kinetic energy), and the fact that the vehicle involved in the injury was “playground equipment”; three pieces of valuable information. Thus the designation of the code W09.9 as ‘Undefined’ is overly general and may misrepresent the utility of the code. Conversely, where a code descriptor does not contain “Other or Unspecified” in the text descriptor (or .8 or .9 terminal digit), it does not necessarily mean that the code descriptor contains useful information for injury prevention. For example, the code W20 (Struck by thrown, projected or falling object) would be classified as a Defined code. What W20 provides information as to the energy source of the injury (struck by = kinetic energy), the only other information it conveys is that the vehicle was a moving object of some sort (i.e. ‘thrown, projected or falling object’). Arguably, W20 is not a higher quality code than W09.9 in terms of the quantity of injury-related information that the code conveys; both provide valuable information regarding some aspects of the injury event; and, both are missing some vital pieces of information – depending upon the context of the research need to which they are being applied.

Evaluations of ICD external cause of injury codes that dichotomise codes as "Defined" or "Undefined" by the above granular method do not evaluate the code system itself beyond basic data quality characteristics (completeness & coder agreement), and do nothing to measure the information value represented by this data in the context of its application. The use of Haddon's Matrix as a framework to dissect and analyse the content of ICD codes in term of elements relevant to injury prevention activities represents a more meaningful and informative conceptualisation. It is the assertion of this thesis that using such a framework would provide a more sensitive and specific measure of quality for injury data.

To-date there have been no studies undertaken that have gone beyond the traditional Defined/Undefined measure of quality to evaluate either the underlying ICD-10 code structure, or the resulting datasets, for their level of 'fit for purpose' to injury research. Thus, a framework is needed to facilitate an evaluation of this nature. "To measure the information quality of an entity, the dimension needs to be grounded meaningfully in measurable attributes of the entity" (Stvilia, Gasser, Twidale & Smith, 2007, p.3). Given that information quality is contextual, an information entity can be of good quality for its original application, but of lower quality in a different context. Thus, information quality must be assessed in its appropriate context. The use Haddon's matrix to contextualise injury data for injury prevention, thereby makes the quality of this data for injury prevention assessable.

Haddon's Matrix provides a valuable structure to guide the conceptualisation and development of injury prevention activities. By compartmentalising an injury event into dimensions of time and contributing factors, the matrix can break a complex problem into more manageable segments (Barnett et al., 2005). Haddon's Matrix could be used to dissect injury data requirements into more manageable segments. Quality data surrounding the host, agent and environment aspects of an injury event are vital for the identification and design of prevention strategies. It has been asserted that the, "Matrix should be employed as a kind of checklist for the development of preventive measures" (Andersson & Menckel, 1995a, p.761). Likewise, the matrix should be employed as a checklist for the development of data collections for injury. Each cell of the matrix represents a distinct locus for identifying strategies to prevent, respond to, or mitigate injuries (Runyan, 1998). Thereby, each cell represents a required data point to inform strategy generation. Realisation of the prevention opportunities presented by the matrix is dependent upon having quality information available regarding the risks and circumstances surrounding the injury event, with which to inform the cells of the matrix table.

A systematic literature search was conducted to investigate whether any exploration of the congruence between external cause of injury codes and Haddon's matrix has been previously undertaken. A systematic search was conducted of Medline, ScienceDirect, EBSCOHost, and Google Scholar, to provide wide coverage academic journals within the health and information management fields, using the following search strategy:

1) (External cause) OR (injury cause); and
2) ICD or ICD-10 or ICD-10--AM or ICD-9 or (External Cause of Injury Code) or E-code; and
3) (Haddon's matrix) or Haddon.

No articles were found that matched the search criteria, indicating that no published work has been undertaken using comparing ICD external cause codes for congruence with the Haddon's matrix framework, a fundamental injury prevention tenet.

To determine if a data collection is capable of supporting injury surveillance, information is required on any limitations of the collection in relation to its capacity to report on pertinent aspects of the injury event. This could be done within Haddon's matrix by scrutinising codes with the ICD-10-AM collection for their coverage of the key epidemiological/injury elements (Host, Agent, Environment). By dissecting a problem into its contributing factors, the Haddon's matrix can be applied as a practical, user-friendly interdisciplinary brainstorming and planning tool (Runyan et al., 2005). Whilst the matrix was designed for planning public health interventions, it is arguable that it could equally be applied to data structure development.

3.3.3 Improving Documentation Quality

If a revised and improved code system is to prove beneficial, the underlying data collection must also be addressed for quality issues. Quality improvement of injury data requires a bottom up approach – starting with the collection of injury information from the scene of the event, or as near after as possible. The content and quality of a coded dataset can be no better than that of the documentation from which it is sourced. The coders however are constrained by both the information recorded within medical records and the codes available within the codes system. Essentially, information within a record can only be accurately and explicitly translated into coded data if there are appropriate codes available within the classification.

It has been asserted that the sources of injury information and injury prevention research possibly rely too heavily on hospitalisation data (Pless & Hagel, 2005). There are many other sources of information available. To improve data quality some of these should be investigated. A report evaluating the value of hospital discharge databases identified that a key strategy to enhancing hospital discharge data quality is to combine it with data from other healthcare sectors (Schoenman & Sutton, 2005). Whilst each independent source of documentation can provide valuable contribution to the description of an injury's circumstances, an individual data source is limited in the ability to individually provide a complete description (Boufous, 2006).

3.3.3.1 Prehospital documentation to inform coding

As discussed in Section 2.5.2.3, ambulance services are the first point of medical contact for many hospitalised injured patients; and are a key agent in the treatment of injury. Approximately 30-40% of all admitted patients arrive to hospital by ambulance (Toloo et al., 2012). In accordance with the suggestion of Schoenman and Sutton (2005), a strategy asserted within this doctoral study is to advance the utilisation of ambulance report forms, for cases transported to hospital by ambulance, to enhance the coding process in-hospital and develop an additional valuable source of injury information for researchers.

Ambulance services occupy a unique position in the health continuum, having direct interaction with the community in their homes, workplaces and public spaces. Ambulance data is available for all levels of severity of cases treated (Davey, Enraght-Moony, Tippett, Freeman, Steinhardt & Wishart, 2007). The inclusion of pre-hospital data serves to provide a more accurate dataset that captures and profiles the full range of injury types and acuities. Paramedics are trained observers, they often have direct access to the scene of injuries (National Center for Injury Prevention and Control, 2009) and therefore opportunities for primary prevention; by witnessing vital information regarding injury causation, identifying risk factors in the community, treating near miss or low acuity injuries, and delivering injury prevention strategies in the community. Additionally, paramedics are directly involved in tertiary injury prevention (injury control) by providing treatment post injury and minimising the impact of the injury. Ambulance services provide a bridge between the patient and the remainder of the healthcare continuum in the care of acute injuries.

Whilst in USA, the National Highway Transport Safety Authority introduced a simplified version of ICD-9 external cause of injury codes for use by ambulance services, ICD codes have not been adopted by Australian ambulance services. During the period of study for this doctoral thesis, Queensland Ambulance Service, upon which this study was based, used paper-based records. These forms, containing minimal coded sections and the majority of detail captured in free prose, have historically contained a rich narrative account of a case's details. Whilst studies have recommended that structured forms can increase data quality and accuracy (Bilston & Brown, 2008), given that code systems to collect this type of information are unproven for their sufficiency to collect comprehensive and pertinent injury information, it would be useful to examine open text to evaluate the extent and nature of information documented when unconstrained by predetermined coded categories. This is particularly timely with the introduction of electronic report forms to prehospital services at a state, national and international level, and the consequential shift away from narrative to coded data collection. Before these collections become limited by the quality of the code options made available within the electronic forms, a baseline data collection capacity for ambulance services needs to be established to facilitate development of data collection forms and coding systems for use in the field.

Logically, prehospital emergency services should be in a key position to provide information regarding the Pre-event, Event and immediate Post-event stages of Haddon's matrix, given their access to the scene of injury and direct interaction with the patient and witnesses, where available. Better utilisation of prehospital records in Queensland hospitals to inform the hospital coding process could potentially lead to improved quality of morbidity data collections for external cause of injury. In addition, if proven to contain detailed information regarding the circumstances of injuries, this source of information could be used to inform future development activities within injury classification.

The assertion of the potential utility of ambulance records for proving cause of injury information is confirmed by a study of clinical coders throughout Australia (McKenzie, Enraght-Moony, Harding, Walker, Waller & Chen, 2008). This study, using a questionnaire methodology, elicited the opinions of this expert group with regards to the relative usefulness of various clinical documentation sources for external cause of injury coding. Coders rated ambulance report forms, where available, to be the best source of information regarding external causes, place of occurrence, and activity at time of injury. Over half of the coders stated that the ambulance report form was a good source of information. Comparatively, the results of this study show that coders viewed discharge summaries, then doctors' notes as the poorest sources of information. Thus, ambulance records present a potentially rich data source to be explored for potential contribution to the collection and improvement of injury-related information.

There are a number of examples available where emergency medical services records have been used for independent injury surveillance (Langley & Chalmers, 1999), or integrated into existing categorical injury surveillance systems (Berry & Harrison, 2007; Langley et al., 2004). Police records have also been evaluated in a number of international studies to supplement injury related datasets (Boufous & Williamson, 2006; Eurosafe, 2013; Rosman, 2001; Cryer, Westrup, Cook, Ashwell, Bridger & Clarke, 2001). In addition, a Swedish study using ambulance data to examine the geographical location of injury found that with ambulances being sent to precise locations of injured persons, ambulance data provides an accurate measure of the location of injury (Cusimano, Marshall, Rinner, Jiang, & Chipman, 2010). The researchers concluded that ambulance records were useful for regular surveillance of moderate and severe injuries, providing essential information for better understanding the spatial aspects of injury.

There is a need to substantiate that prehospital records contain reliable external cause of injury information. A systematic literature search was conducted to rigorously explore whether any existing studies have assessed the availability of external cause of injury information within prehospital emergency services documentation.

Initially the Cochrane Controlled Trials Register, Cochrane Injuries Group Trials Register, Cochrane Prehospital and Emergency Health Trials Register, and NHS Emergency Care Specialist Library (http://libraries.nelh.nhs.uk/emergency/) were all searched to establish whether a similar review has already been conducted. No relevant reviews were found. Literature searching within the health information management field has been reported to be problematic due to a lack of established, specialised information science bibliographic resources, and the lack of entrenched and commonly agreed keyword terms (Haddon, 1995). Hence, a broad research strategy was adopted, as defined below.

Electronic database search strategies developed for use with EBSCOHost were adapted to search for published studies cited in Medline, CINAHL, Pre-CINAHL and Health Source: Nursing/Academic Edition databases between January 1975 (January 1982 for CINAHL/Pre-CINAHL) and January 2013. Search strategies used in

Medline were modified from the Cochrane search strategies developed by the Prehospital and Emergency Health, and the Injuries Group. As CINAHL and Health Source do not use MeSH terms, the search strategies were adapted by removing these headers, and searching for the text terms in default fields (i.e. title, abstract, full text).

Components of the search strategy relating to Prehospital Emergency Medical Services MeSH Terms were:

#1 emergency medical services+ OR #2 emergency medical technicians+ OR #3 ambulances+

Text Terms

#4 prehospital OR #5 pre-hospital OR #6 paramedic OR #7 ambulance* OR #8 out-of-hospital*

Components of the search strategy related to Injury:

MeSH Terms

#9 Wounds and Injuries+ OR #10 Suicide+ OR #11 Violence+ OR #12 Accidents+ OR

Text Terms

#13 accident OR #14 injur* OR #15 crash* OR #16 trauma OR #17 suicid OR #18 violen**

Components of the search strategy related to Documentation:

MeSH Terms

#19 Medical Records+ OR #20 Documentation+ OR #21 Classification+ OR #22 International Classification of Diseases OR

Text Terms

#23 Medical Record OR #24 Document* OR #25 Classification* OR #26 International Classification of Diseases*

Components of the search strategy related to Quality:

#36 Quality OR #37 Validity OR #38 Reliability OR #39 Sensitivity OR #40 Specificity OR #41 Positive Predictive Value OR #42 Consistency OR #43 Completeness

The following journals were hand searched: Injury Prevention; Accident Analysis and Prevention; Annals of Emergency Medicine; Emergency Medicine (Australia); Prehospital Emergency Care for the period 2005 to 2013. A snowballing technique was employed by hand-checking the reference lists of any identified papers to find additional studies published during the time period 2005 to 2013. Finally, grey literature was searched for using Google search engine and a combination of the text search terms from the database search strategies, however this yielded no results.

In Medline, the initial search strategies yielded 1,552,012 for the Prehospital search terms, 403,353 records for the Injuries search terms, and 419,363 articles for the Documentation search terms. The Prehospital, Injury, and Documentation search strategies were combined using the AND function, yielding 5022 articles. Finally, the Quality search terms were subsequently included, reducing the pool to 522 potential articles. Hand searching, snowballing of reference lists, and sources of grey literature were then conducted to identify any further reports that were eligible for inclusion. No additional records were identified.

Inclusion criteria for review were:

- any studies which involved persons treated by a prehospital emergency medical service for acute care following injury; where,
- outcome measures included rates of completion for external cause of injury outcome information; Kappa value measures of agreement between ambulance reports and other data sources for external cause of injury information; or, measures of precision of external cause of injury information coded with a standardised classification system.

Once the stated inclusion criteria were applied to the electronic search records, eleven articles were identified for detailed review: (Bercher, Staley, Turner, & Aitken, 2001; Bilston & Brown, 2008; Boergerhoff, 1999; Dick & Baskett, 2000; Grant, Gregor, Beck, & Maio, 2000; Grant, Gregor, Maio, & Huang, 1998; Husni, Linden, & Tibbles, 2000; Langlois et al., 1995; Razzak, Luby, Laflamme, & Chotani, 2004; Sonnenfeld, Bailey, Bradshaw, Crosby, & Askland, 2002; Staff & Sovik, 2011). These articles were then manually screened by the author of this thesis; subsequently, only four studies were selected for inclusion. One report (Dick & Baskett, 2000) was excluded as it was a policy document and presented no analysis of the comprehensiveness of current ambulance documentation for external cause of injury information. Four studies (Bercher et al., 2001; Husni et al., 2000; Razzak et al., 2004; Sonnenfeld et al., 2002) were excluded as they were surveillance studies, with cases selected for inclusion based upon the documented external cause information (ie. attempted suicide and assault, respectively). The researchers who conducted these studies did not evaluate the number of records that had been omitted from the sample selection due to a lack of external cause information, nor the accuracy and level of detail of the information recorded in those records that were studied. The two remaining reports, (Grant et al., 2000; Grant et al., 1998) were excluded as they did not include an evaluation specifically of external cause information, but rather analysed this as a component of overall quality of the injury-related documentation. Additionally, the study by Grant (2000) excluded cases where any information was missing in the medical documentation.

The four (4) included studies were those that reported completion rates and/or precision of external cause of injury information in ambulance records, or compared standardised classification systems for coding this information. Meta-analysis was not appropriate, due to the small number of studies included, their heterogeneous designs, and descriptive methodologies. A description of the four selected studies is presented following.

Boergerhoff (1999) evaluated the potential for the use of out-of-hospital data to inform surveillance of violent injuries. The aim of this study was to examine the extent to which paramedics can adequately collect information about injuries in the field, to facilitate identification of intentional injuries. The study used a prospective data collection methodology, using a modified version of the standard ambulance report form. All report forms during a 3 month period were collected and analysed for completeness and quality of documentation regarding the presence of violence-related injury. Overall, quality and comprehensiveness of ambulance documentation was poor for violence-related injuries. Of all records reviewed, 73% of cases had documentation errors, with more than 99% of these reports containing errors of omission. Information regarding domestic abuse screening was missing from more than 99% of run reports for female patients.

The study of Langlois et al. (1995) examined the quality of external cause coding for hospitalised injuries using a retrospective medical record review process. All cases discharged during the study period for an injury or poisoning related diagnosis were selected for analysis. The quality of available documentation sources (hospital inpatient, EMS, ED etc.) for specific external cause information was evaluated through a recoding process. Two experts in classification recoded the narrative external cause information within each documentation source, and as a combination of all sources. Two researchers then reviewed these recodings to establish the reliability and validity of the assigned codes. Despite the methodology involving separate coding based upon each separate documentation source, the only results that were presented for prehospital documentation was in a single graph. The graph showed that specific cause of injury information was not present for in excess of 70% of ambulance records. The methodology states that narrative information within the record was recoded for the expert review. No information was included, however, as to how external cause information was able to be recorded within the ambulance report form (i.e. narrative only, coded, or combination of two). Additionally, no evaluation was presented for Place of Occurrence codes, and activity at time of injury could not be evaluated as this version of the ICD code system did not include this element.

The study by Bilston and Brown (2008) examined hospital and ambulance records for the accuracy of information regarding child restraint usage and crash characteristics in motor vehicle crashes. Of 46 patients, ambulance records were not available in 39% of cases. However, where records were available, the information was generally complete (78-100%), and accurate (52-89%) for information regarding restraint type, seating position, correct restraint use, and crash factors such as crash direction and injury severity. A second study of ambulance records for motor vehicle crashes was identified (Staff and Sovik, 2011). The only external cause of injury aspect that was evaluated was mechanism of injury. The study found that of 392 patients, 80% of road ambulance and 92% of air ambulance patients had mechanism of injury information recorded in their medical record.

As evidenced by the above discussion, there is a dearth of evidence available regarding the comprehensiveness of ambulance documentation for external cause of injury information. The limited studies that are available have methodological limitations, and are not representative of the advanced prehospital emergency care systems present in Australia. The one study that did examine the level of detailed external cause information within the ambulance record, for the full spectrum of injury mechanisms, only provided a single very summary measure (Langlois et al., 1995). The second study (Boergerhoff, 1999), examining only a single intent group (violence-related injuries), found ambulance records to have poor levels of documentation. However, violence-related injuries are a problematic group to study as documentation is often lacking in hospital medical records (Gielen & Sleet, 2003; Janz & and Becker, 1984; Hagberg et al., 1997). This is likely due to the sensitive nature of these injuries, and reluctance on the part of the victim and medical staff to report for fear of repercussions. A further weakness of the studies is that there is no evaluation of the availability of Place of Occurrence or Activity at Time of Injury information within the ambulance records. By comparison, the two studies of ambulance documentation for motor vehicle crashes, whilst only involving small sample sizes, nonetheless demonstrate capacity to elicit useful injury cause information from prehospital records.

Despite the use of a simplified form of ICD-9 external cause coding for prehospital emergency services in the United States, no studies were available regarding the precision of this, or other standardised code systems, for use in the field. The lack of evidence regarding the availability and quality of external cause of injury information within ambulance records represents a significant gap in knowledge if this data is to be capitalised on in order to facilitate hospital morbidity coding, injury surveillance and research activities.

3.3.4 Summary of Improving Injury Data Quality

Whilst hospital morbidity data collections coded with ICD external cause of injury codes are a core data source for injury prevention research, criticism abounds of their accuracy and precision for this purpose. The lack of quality data for injury prevention activities is hampering progress in this area.

Hospital morbidity external cause of injury data quality is limited by two key factors, the nature and content of clinical documentation available to inform the clinical coding process, and characteristics of the classification system in use. However, the small number of studies available regarding the quality of ICD-10-AM external causes of injury codes are limited to examining only base data quality characteristics of coder agreement (i.e. measure of coding error) and completeness (i.e. missing data). Additionally, the underlying ICD-10-AM code system has never been evaluated for its 'fit-for-purpose' for injury prevention and control formulation. Thus, designing improved hospital data for injury research requires a two-fold approach:

- Improve external cause of injury code systems
- Improve clinical documentation for cause-of-injury injury information, to facilitate the clinical coding process

In order to achieve these two goals, there is a need to ground injury data collections in injury prevention theory, to establish a framework for evidence-based code system development, and to explore opportunities to gather injury causation data from a broader array of clinicians involved in treatment, in particular paramedics given their unique intersect between community and hospital settings. This doctoral thesis proposes to apply Haddon's matrix for this aim (as proposed in Section 3.3.2), to evaluate the fit-for-purpose of ICD-10-AM external cause of injury codes, hospital morbidity data, and clinical documentation (in particular ambulance records) to injury prevention research.

3.4 *Research Outline*

Chapter Two of this thesis established the centrality of injury data to effective injury prevention research. A description was provided of the development and evaluation of ICD-10-AM external cause of injury codes, the classification system employed in Australian hospitals for the coding of injury data from medical records. Additionally, the impacts of classification system structure and content impacts upon the quality of the resultant hospital morbidity dataset are discussed. Section 2.5.2 extended the discussion of injury data quality beyond ICD-10-AM code system structure to several factors affecting data quality. These elements are summarised in **Figure 10** below.

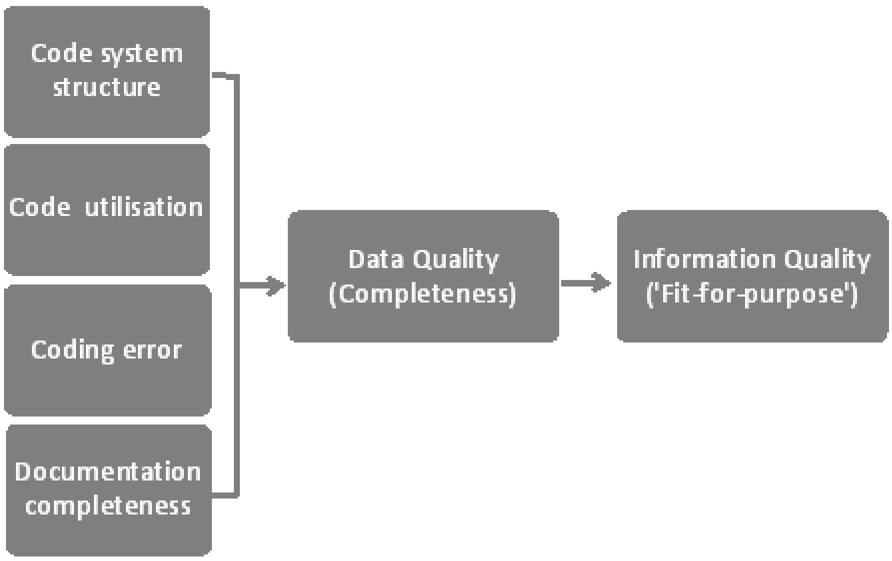

Figure 9 Components of a Quality Data System

1. Code system characteristics – arrangement (pre-coordination/post-coordination; compiled code strings vs. multiple associated codes etc.) and content (availability and appropriateness of codes) of the injury data classification system in use.

- the arrangement and availability of appropriate codes within the code system impacts upon the ability to accurately translate written information (where available) into precise codes. An incomplete or improperly structured code set impacts upon the accuracy of the coding process, potentially introducing higher levels of coding errors due to ambiguity.

2. Code utilisation – application of the ICD-10-AM codes to actual datasets.

- particular codes from within ICD-10-AM code system are applied to the hospital morbidity dataset dependent upon the nature and characteristics of the injury event, the information available within the medical records, the coding decisions of the clinical coder and the structure and content of the classification system. Consequently, codes comprising the resultant dataset are likely to vary in proportions of high and low quality codes compared to the frequency within the underlying codes system.

3. Coding error – accuracy with which information in medical records is translated from text to code.

- a measure of the completeness with which narrative information is translated to coded data. Errors can be introduced to the data during this process due to misinterpretation of documented information, ambiguity in coding rules, and random coder error.

4. Documentation completeness - structure and comprehensiveness of the documentation, and compliance of documenting clinicians with gathering and recording accurate and complete information.

- the ability to assign detailed injury codes that provide accurate information regarding the circumstances of an injury event is dependent upon the completeness of information in the source documentation.

5. Data Quality - a description of theoretical data quality; a measure of data completeness.

- code system characteristics, documentation completeness and coding accuracy interrelate to form overall data completeness. Data completeness may be reduced by deficiencies in any or all of these aspects.

The small group of studies available that examine ICD-10-AM external cause of injury data quality have focused either on coder accuracy, or the data quality (completeness) of resultant datasets. Data quality has been operationalised based upon whether the ICD-10--AM code descriptor contains the words "Unspecified" or "Other Specified" (or a terminal .8 or .9 digit), thereby denoting the code as an 'Undefined' code (or residual "dump" code). Consequentially, all other codes are by default described as 'Defined'. This indiscriminate categorisation is not based upon the nature or usefulness of the entire information contained within the code descriptor; nor upon the suitability of the information contained within that code for the end purpose of injury research. This imprecise method of operationalizing completeness is too granular to accurately summarise the overall quality of complex, multifactorial codes such as ICD.

Chapter 3 extends the discussion of data quality beyond a simple measure of 'completeness' to one of 'fit-for-purpose'. The proposed 'fit-for-purpose' conceptualisation is adopted from industry and provides an applied measure of quality (information quality) in context of the data application.

6. Information Quality: (**Figure 9**)

- a measure of the appropriateness of the entire data system for the purpose to which it is being applied (injury prevention research)
- dependent upon data completeness (thus affected by code system structure, documentation completeness & accuracy of the coding process)
- fit-for-purpose is context dependent, thus an operational definition of intended use is required to be assessed against

Haddon's Matrix, a fundamental framework for injury epidemiology and prevention, is used as a basis for identifying and understanding the causes of injury events, and for developing strategies to ameliorate such events in the future. In order to identify and develop effective prevention strategies, data is required to inform the cells of the Haddon's matrix. Consequently, it is logical that any classification system used to code data for the primary purpose of injury prevention research should align to or be compatible with this theoretical foundation. This thesis asserts that Haddon's matrix provides an appropriate framework to evaluate the fit-for-purpose of injury information and coded data.

Despite the identified importance of data to effective injury prevention, review of the literature establishes that there is a dearth of research demonstrating systematic appraisal of the quality and suitability of ICD-10-AM external cause of injury codes to injury research applications. ICD-10-AM has been developed independently of injury researchers or injury framework, and to date there have not been any rigorous studies of the correspondence between available codes and the information requirements of injury prevention research. Neither the underlying ICD-10-AM classification system, nor resultant coded datasets (e.g. hospital morbidity data) have been evaluated in terms of their 'fit for purpose'.

Based upon the small literature base evaluating ICD-10-AM external cause of injury codes, and expert opinion within the injury research field, it is expected that hospital external cause of injury morbidity data will experience deficiencies in terms of 'fit-for-purpose'. Thus, there is a need to develop this data to enhance its utility for injury research. This requires a three-prong approach:

1. Develop the data classification system;
2. Improve coder accuracy; and
3. Enhance clinical documentation.

In order to inform development of the data classification system, this study will use Haddon's matrix framework to evaluate the impact of each of the components of data completeness (**Figure 9**), and the overall utility of ICD-10-AM coded external cause of injury data, for injury prevention research. Improving coder accuracy primarily requires educational strategies, so whilst this study will assess the impact of coder error on information quality, it is outside the scope of this research to design improvement strategies in this area. A strategy to enhance injury data collections, including hospital morbidity data, by improving the content of clinical documentation for external 3.3.3.1 cause of injury information will also be evaluated. Ambulance records have the potential to provide valuable information regarding the circumstances of injury for patients treated by paramedics. This research will validate the utility of ambulance documentation for provision of injury information.

In summary, there are four key aims of this research:

1. To trial an epidemiological framework to assess the 'fit-for-purpose' of ICD-10-AM external cause of injury codes, and coded data, for injury research;

2. To evaluate the 'fit-for-purpose' of ICD-10-AM coded external cause of injury information within the Queensland Hospital Admitted Patients Data Collection;

3. To identify causes of poor information quality within the Queensland Hospital Admitted Patients Data Collection external cause of injury data;

4. To measure the completeness of injury information within medical records and evaluate the potential to enhance current external cause of injury data through improved utilisation of ambulance documentation.

The research aims will be addressed across three separate sub-studies that will each address aspects of external cause of injury data completeness and information quality. For the purpose of demonstration, two example external cause broad categories are used throughout the body of the thesis; transport & falls.

CHAPTER 4. ICD-10-AM CODE SYSTEM ANALYSIS (Study1)

4.1 Background

Chapters Two and Three of this thesis provided a description of the development and evaluation of ICD-10-AM external cause of injury codes and their application to hospital morbidity data collections and injury prevention research. There is a dearth of research in this area. Traditionally the small group of studies available have not evaluated the underlying structure of ICD-10-AM external cause of injury codes per-se, but rather the quality of resultant data coded with this code system. The assessments have based upon a rudimentary definition of data completeness operationalised as whether the code descriptor is 'Undefined' (i.e. contains the words "Unspecified" or "Other Specified"; or a terminal .8 or .9 digit); by default, all other codes are described as 'Defined'. This indiscriminate categorisation is not based upon the nature or quality of the entire information contained within the code descriptor; or upon the suitability of the information contained within that code for the end purpose of injury research. The resulting measure is too granular to accurately summarise the overall quality of complex, multifactorial codes such as ICD-10-AM external cause of injury codes.

In response to the identified weaknesses with evaluating ICD-10-AM external cause of injury codes as 'Defined' or 'Undefined' based upon these traditional criteria, Section 3.2.1 introduced the concept of 'fit-for-purpose'. Haddon's Matrix is a fundamental framework for injury epidemiology and prevention, used as a basis for identifying and understanding the causes of injury events and for developing strategies to ameliorate such events in the future. It was asserted that this framework presents a mechanism by which to evaluate the alignment between ICD-10-AM external cause of injury coding and injury prevention theory. To-date there has not been any rigorous studies of the correspondence between ICD-10-AM external cause of injury data and the 'fit-for-purpose' of injury research.

The purpose of this first study is to trial the Haddon's Matrix conceptualisation of 'fit-for-purpose' and compares it to the traditional 'Defined/Undefined' data completeness measure. The available literature to-date has studied ICD-10-AM external cause of injury codes 'in action'; leading to a confounding of the results by other factors (i.e. aside from the code system structure), that impact data completeness. The analysis undertaken in Study 1 will be of the underlying code system, absent of the impact of documentation characteristics or coder error (**Figure 10**).

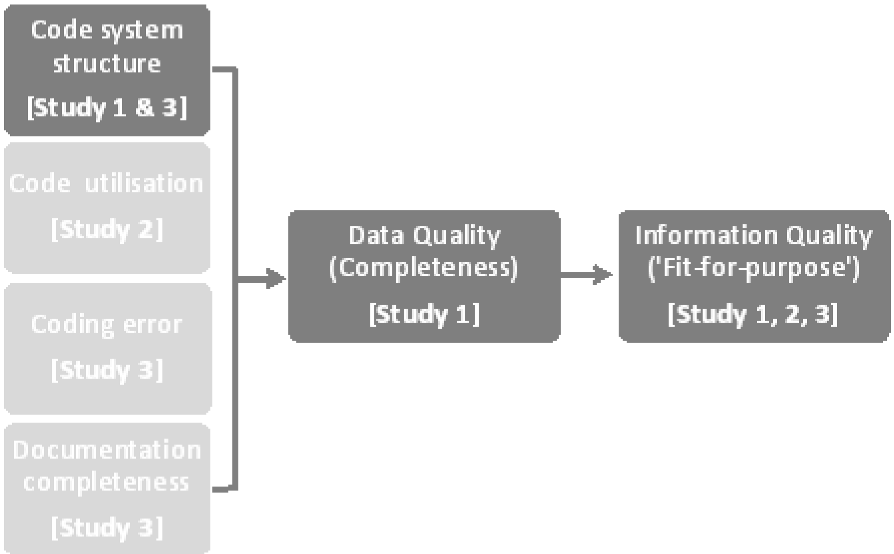

Figure 10 Study1 Contribution

4.2 *Key Objectives*

The objective of this study is to conduct analysis of external cause of injury codes within the underlying ICD-10-AM classification system to:

1. Determine the data completeness of the ICD-10-AM code system for external cause of injury codes using 'traditional' Defined/Undefined code categorisations;

2. Determine the information quality of the ICD-10-AM code system for external cause of injury codes using a Haddon's Matrix conceptualisation of 'fit-for-purpose';

3. Compare the relative effectiveness (completeness of coverage, specificity, false negative and false positive rates) of the Defined/Undefined 'data completeness' measure to the Haddon's Matrix 'information quality' conceptualisation; and

4. Identify priority areas within the ICD-10-AM external cause of injury code system for quality improvement activities.

4.3 *Research Questions*

The following research questions address the key objectives:

1. a. What percentage of codes are 'Undefined' (poor data completeness) within the ICD-10-AM external cause of injury code set?
   b. Does the proportion of 'Undefined' codes vary by injury mechanism and intent?

2. a. What percentage of codes contain information that relates to each of the Haddon's injury elements (Host, Agent, Environment)?
   b. Does the percentage differ by injury mechanism and intent?

3. a. To what degree does the traditional 'Defined/Undefined' view of quality over- or under-estimate ICD-10-AM code quality compared to the Haddon's matrix model?
   b. Does the Haddon's Matrix conceptualisation provide a more comprehensive coverage and a more specific measure of code quality than the 'traditional' Defined/Undefined categorisation?
   c. Is there any difference by injury mechanism and intent?

4. Can high priority code blocks for quality improvement be identified, due to a low prevalence of Haddon's elements (Host, Agent, Environment information)?

4.4 *Method*

4.4.1 Ethical Clearance

The study design was exempt from the requirement for ethical approval due to the use of publicly available data only (i.e. a published code system). No data relating to identified persons was used in any analyses in this study.

4.4.2 Study Design and Setting

The study involved analysis of a nationally utilised health information classification system, ICD-10-AM. The data used in this study were from the fourth edition of the Australian Modification of the International Classification of Diseases (ICD-10--AM 4th ed) Chapter XX (External Cause of Morbidity & Mortality) code system, sourced from the National Centre for Health Information Research and Training (NCHIRT), as this was the edition in operation for the hospital data in Studies 2 & 3. All codes pertaining to "community injuries" within ICD-10-AM Chapter XX (code range *V00-Y98)* were included for analysis. (See Section 2.2.1 for discussion relating to community injuries).

The study was carried out at NCHIRT (formerly known as the National Classification in Health (NCCH)), a Queensland University of Technology (QUT) research centre.

4.4.3 Data preparation

Data preparation was conducted using Microsoft Excel and SPSS (Statistical Package for Social Sciences Version 15). To prepare the data for analysis, the procedure was as follows:

1. Alphanumeric ICD codes were split into two variables: a string variable for the alpha portion; and, a numeric variable for the numeric portion of the ICD codes, to enable case selection based on alpha and numeric code range restrictions;

2. Each ICD10--AM external cause codes were categorised as:

    - *Defined* / *Undefined* to characterise the degree of specified information contained within a code. Codes or code blocks that attribute a specific external cause at a particular level of description (i.e. 3rd or 4th character digit) were described as *Defined* codes.

    - *Undefined* codes (i.e. 'Other specified', 'Unspecified', and 'Other and Unspecified' codes), were characterized as 'residual' codes that function as 'catch-all' categories. These categories provide an opportunity to record some information about the external cause even though the specific detail is either not recorded in the medical record and/or not defined specifically in the classification.

Using these definitions of Defined/Undefined codes, all codes within the selected code ranges for the study, were categorised. This process was performed independently by the student and a Supervisor, and then compared, to ensure uniformity of the categorisation. Discrepancies in code categorisation between researchers were reviewed until mutual consensus was reached. These categorisations have been utilised in previous published studies (McKenzie et al., 2006) and are displayed in **Appendix 1**.

3. For each of the 2,240 external cause of injury codes the text descriptor (e.g. V20.02 'Motorcycle rider injured in collision with pedestrian or animal, driver, non-traffic accident, motorcycle designed primarily for off-road use') was manually interrogated by the student to separately identify information relating to each of Haddon's elements (Host; Agent (Energy, Vector/Object & Vehicle/Perpetrator); Environment):

    a. Host information relates to the human factors involved in the injury event.
    b. Agent information includes the form of Energy, any Vector (animate object), Vehicle (inanimate object) or Perpetrator (for Assault cases) that was involved in the injury event.
    c. Environment includes the physical and social conditions present at the time of the injury.
    d. Where an element was not relevant to a particular code (e.g. 'Perpetrator' information for an unintentional injury), the relevant variable was coded '99' (Not Applicable), to enable these cases to be removed from analyses pertaining to this element.
    e. All information within the text code descriptor was manually extracted and each element was stored in a separate variable for analysis. This examination was initially performed by the student, and then reviewed by a Supervisor; in the event of different categorisations the student deferred to the expertise of the Supervisor.

4. Using the parsed code text descriptors, dichotomous variables were generated to indicate ['1'] presence and ['0'] absence of information in the code relating to each Haddon's element (Host/Agent [Energy, Vector/Object & Vehicle/Perpetrator]/Environment).

5. There are a large number of codes, code blocks, and broad categories which make up the hierarchy of the ICD-10--AM external cause chapter. For

standardised presentation of results in this study, all ICD-10-AM codes were recoded into groupings by their relevant mechanism/intent block according to the categories used in the international ICD-10- External Cause of Injury Mortality Code Matrix (see **Appendix 2** for a copy of the matrix with the ICD-10 code ranges for each matrix cell). This is an internationally adopted framework jointly developed by the Injury Control and Emergency Health Services section of the American Public Health Association and the International Collaborative Effort (ICE) on Injury Statistics. The purpose of this two dimensional array is to group ICD-10 mortality codes into homogenous groups by mechanism and intent (e.g. unintentional fall, intentional cut/pierce) for the purpose of uniform analysis and reporting (NCHS. ICD–10: External cause of injury mortality matrix [online], available from: http://www.cdc.gov/nchs/injury/injury_matrices.htm) The matrix has been developed for use with mortality data, however due to the structural similarity of the codes systems is applicable to morbidity data at the fourth digit level for ICD-10-AM external cause codes.

4.5 *Analysis Methods*

4.5.1 Data Completeness and Information Quality

Statistical analysis of ICD-10-AM 4th Edition External Cause of Injury codes (Chapter XX) was performed to evaluate the data quality and information quality of underlying ICD-10-AM external cause of injury code set, and to compare the performance of the traditional “Defined/Undefined” and proposed “Haddon’s Matrix” measures of quality. All analyses were performed using SPSS Version15.

1. Data Completeness:

   The outcomes of these analyses are descriptive statistics identifying the prevalence of “Defined” and “Undefined” codes amongst ICD-10-AM code set, to evaluate the completeness of ICD-10-AM codes. An ‘Undefined’ code represents poor data quality with missing information; “Defined” codes being of higher quality and communicating specific information.

2. Information Quality:
    a. The parsed text descriptors relating to each Haddon’s element for each code will be presented to demonstrate the nature of textual information provided by ICD-10-AM codes, and to outline how the degree of detailed information, and number of descriptive elements varies by mechanism and intent for each Haddon’s element.

    b. Prevalence of “Haddon’s Elements Present” and “Haddon’s Element Absent” codes. This descriptive analysis provides a measure of the information quality of ICD-10-AM external cause of injury codes by evaluating their coverage of key injury elements. Where information is present relating to an aspect of Haddon’s Matrix (i.e. Haddon’s Matrix Present), this represents a high quality code containing specific pertinent information for injury research. Where there is no pertinent information (“Haddon’s Matrix Absent”) the code is considered of lower information quality, as this represents a loss of valuable information to inform the completion of cells within the matrix.

3. Relative effectiveness of the proposed Haddon’s Matrix (fit-for-purpose) conceptualisation of ‘information quality’ compared to the traditional “Defined/Undefined” ‘data quality’ measure.

    a. The concordance between code “Defined/Undefined” and “Haddon’s Present/Absent” status was analysed using crosstabs tables. Analysis was performed to calculate the completeness of coverage, specificity, false negative and false positive rates of the “Defined/Undefined” categorisation compared to the Haddon’s method, as presented below in **Figure 11**.

		ICD-10-AM		
		Haddon's Present	**Haddon's Absent**	
ICD-10-AM	**Defined**	Completeness of coverage (True +ve)	False +ve	Total Defined
	Undefined	False -ve	Specificity (True –ve)	Total Undefined
		Total Present	Total Absent	

Figure 11 Defined/Undefined vs Haddon's Matrix Analysis

b. True positives were those codes identified as "Defined" that had the relevant Haddon's element "Present".

c. Completeness of coverage: As no gold standard measure was available with which to assess the two quality measures (Defined/Undefined vs Haddon's matrix), the two methods were compared to each other. Where there is no gold standard for comparison, the resulting statistic is referred to as 'completeness of coverage', which is an estimate of sensitivity (Klaucke, 2000; Romaguera, German, & and Klaucke, 2000). The Haddon's conceptualisation was used as the comparator (proxy gold standard) for these analyses. Completeness of coverage percentage was calculated as [N(True +ve) / N(Total Present) *100].

d. Specificity: this comparison provides a measure of the relative specificity of the two methods being compared based upon the proportion of true negatives. True Negatives were those codes identified as "Undefined" that were also categorised as "Haddon's Element Absent".

True negative percentage was calculated as:
[N(True -ve) / N(Total Absent) *100].

e. The False Positive (FP), or Type I error rate, equals [1 – Specificity] and provides a measure of the overestimation of quality obtained using the "Defined/Undefined" categorisation compared to the Haddon's method. False positives occur when a code is identified as "Defined", but conversely is determined not to contain useful injury information under the Haddon's conceptualisation.

f. The False Negative (FN), or Type II error rate, equals [1- Completeness of Coverage] and gives a measure of the under-estimation of quality obtained using the "Defined/Undefined" categorisation compared to the Haddon's method. False negatives occur when a code is identified as "Undefined", but conversely is determined to contain useful injury information under the Haddon's conceptualisation.

g. Overall percentage agreement between Defined/Undefined and Haddon's Matrix was calculated as:

[(n(Haddon's Present & Defined) + n(Haddon's Absent & Undefined)) / Total number of codes in code block *100]

h. Priority areas for improvement were identified as code blocks with a high prevalence of "Haddon's Element Absent" codes in the code structure

For distributional analyses only raw percentages are reported as the entire code set (i.e. 'code population') is included in the analysis, therefore precluding the need for confidence intervals.

Results of the analyses were formatted for presentation within the ICD-10 External Cause of Injury matrix format in use internationally to assemble the codes into meaningful groups for interpretation.

The results matrices are displayed for Defined/Undefined code breakdowns and each Haddon's element separately (Host; Agent [Energy, Vector/Object, Vehicle/Perpetrator]; Environment) with Completeness of Coverage and Specificity results displayed.

Whilst it is acknowledged that Australian hospitalisation data includes both primary external cause (intent-mechanism-object) code AND a place of occurrence code (of which environment information may be captured), these need to be treated separately in this analysis of the code system as they are distinct elements in the classification. Furthermore, place of occurrence refers to a more broad infrastructure type location (e.g. school, home, highway), while the type of environment information captured in the primary external cause code is a more specific location within the infrastructure place of occurrence code. Therefore, it makes sense to consider these two elements distinctly.

4.6 *Results*

4.6.1 ICD-10-AM External Cause of Injury Code System

In total, 2,240 individual codes within the ICD-10-AM external cause of injury chapter (Chapter XX) were examined. The majority of codes (76%) are within the Unintentional injuries category, whilst 20% are Assaults, and 2% each are Self-Harm and Undetermined intent code categories.

When the ICD-10-AM external cause of injury codes are examined by broad injury mechanism groups, the majority of codes are contained within the Transport Accidents block (70 %) (**Table 2**). The next largest code group is the Poisonings block, containing 5% of the total codes, and in combination Other Specified and Unspecified mechanism of injury codes represent 4% of the total codes examined.

Table 2 ICD-10-AM Code Distribution by Injury Mechanism

Injury Mechanism	N	% of Total Codes
Cut/Pierce	78	4%
Drowning	72	3%
Fall	47	2%
Fire/hot object or substance	51	2%
Firearm	79	4%
Machinery	20	1%
Natural/Environmental	80	4%
Overexertion	1	<1%
Poisoning	102	5%
Struck by or against	32	1%
Suffocation	21	1%
Transport (All)	1559	70%
Other Specified, Classifiable	71	3%
Other Specified, nec	14	1%
Unspecified	13	1%
Total	2240	100%

4.6.2 Traditional Defined / Undefined Code Blocks

Conventionally, the data quality of ICD-10-AM external cause of injury codes is described in terms of 'Defined' or 'Undefined' code status. Further details of the Defined/Undefined categorisations used in these analyses are presented in **Appendix 1**.

4.6.2.1 **Overall and Intent Blocks**

Overall, 92% of codes of ICD-10-AM codes are denoted as Defined, indicating high data completeness using this measure of quality. (**Table 3**) The lowest rate of Defined codes is within the Self Harm intent block (69% Defined), and the highest proportion is amongst the Unintentional injury codes (97%). Assault and Self harm code blocks both contain approximately three-quarters 'Defined' codes.

4.6.2.2 **Mechanism Code Blocks**

The highest proportion of Defined codes was within the 'All-Transport' code block (98%). (**Table 3**) Within the mechanism code blocks for 'Firearm', 'Natural/Environmental', 'Other Specified, Classifiable', 'Fall', 'Machinery', 'Overexertion', 'Struck by or against', and 'Suffocation' in excess of 80% of codes are Defined. The proportion is lower in the 'Cut/Pierce', 'Drowning', 'Poisoning', and 'Other Specified, Not elsewhere classified' code blocks, where approximately two-thirds of codes are Defined. The lowest quality code blocks are the 'Fire/Hot object or substance' code block (55% Defined) and 'Unspecified' codes (0% Defined).

Table 3 ICD-10-AM Traditional "Defined/Undefined" Code Quality

DEFINED / UNDEFINED		All Intents		Unintentional		Self Harm		Assault		Undetermined	
		n	%	n	%	n	%	n	%	n	%
All Injury	Defined	2065	92	1656	97	33	69	338	77	38	78
	Undefined	175	8	47	3	15	31	102	23	11	22
	Total	**2240**	**100**	**1703**	**100**	**48**	**100**	**440**	**100**	**49**	**100**
Cut/Pierce	Defined	54	69	6	100	4	67	40	67	4	67
	Undefined	24	31	---	0	2	33	20	33	2	33
	Total	**78**	**100**	**6**	**100**	**6**	**100**	**60**	**100**	**6**	**100**
Drowning	Defined	46	64	10	83	3	60	30	60	3	60
	Undefined	26	36	2	17	2	40	20	40	2	40
	Total	**72**	**100**	**12**	**100**	**5**	**100**	**50**	**100**	**5**	**100**
Fall	Defined	44	94	32	91	1	100	10	100	1	100
	Undefined	3	6	3	9	---	0	---	0	---	0
	Total	**47**	**100**	**35**	**100**	**1**	**100**	**10**	**100**	**1**	**100**
Fire/hot object or substance	Defined	28	55	24	89	2	100	---	---	2	100
	Undefined	23	45	3	11	---	0	20	100	---	0
	Total	**51**	**100**	**27**	**100**	**2**	**100**	**20**	**100**	**2**	**100**
Firearm	Defined	67	85	6	100	5	83	50	83	6	86
	Undefined	12	15	---	0	1	17	10	17	1	14
	Total	**79**	**100**	**6**	**100**	**6**	**100**	**60**	**100**	**7**	**100**
Machinery	Defined	20	100	20	100						
	Undefined	---	---	---	0						
	Total	**20**	**100**	**20**	**100**						
All Transport	Defined	1530	98	1440	98	4	50	78	98	8	100
	Undefined	29	2	23	2	4	50	2	3	---	0
	Total	**1559**	**100**	**1463**	**100**	**8**	**100**	**80**	**100**	**8**	**100**
Natural / Environmental	Defined	73	91	73	91						
	Undefined	7	9	7	9						
	Total	**80**	**100**	**80**	**100**						
Overexertion	Defined	1	100	1	100						
	Undefined	---	0	---	0						
	Total	**1**	**100**	**1**	**100**						
Poisoning	Defined	70	69	10	71	10	71	40	67	10	71
	Undefined	32	31	4	29	4	29	20	33	4	29
	Total	**102**	**100**	**14**	**100**	**14**	**100**	**60**	**100**	**14**	**100**
Struck by or against	Defined	32	100	10	100	1	100	20	100	1	100
	Undefined	---	0	---	0	---	0	---	0	---	0
	Total	**32**	**100**	**10**	**100**	**1**	**100**	**20**	**100**	**1**	**100**
Suffocation	Defined	19	91	7	78	1	100	10	100	1	100
	Undefined	2	10	2	22	---	0	---	0	---	0
	Total	**21**	**100**	**9**	**100**	**1**	**100**	**10**	**100**	**1**	**100**
Other Specified, Classifiable	Defined	60	85	17	94	2	100	39	80	2	100
	Undefined	11	16	1	6	---	0	10	20	---	0
	Total	**71**	**100**	**18**	**100**	**2**	**100**	**49**	**100**	**2**	**100**
Other Specified, nec	Defined	10	71	---	0	---	0	10	91	---	0
	Undefined	4	29	1	100	1	100	1	9	1	100
	Total	**14**	**100**	**1**	**100**	**1**	**100**	**11**	**100**	**1**	**100**
Unspecified	Defined	---	0	---	0	---	0	---	0	---	0
	Undefined	13	100	1	100	1	100	10	100	1	100
	Total	**13**	**100**	1	100	1	100	10	100	1	100

4.6.2.3 **Place of Occurrence Codes**

In total, there are 60 Place of occurrence codes within the ICD-10-AM code system. (**Table 4**) Place of Occurrence codes are used to record details regarding the location type of injury events. Analysis of these codes using the Defined/Undefined categorisation classifies 24 (40%) of codes as Undefined, due to their containing "Other or Unspecified" in the text descriptor, or a .8 or .9 terminal digit in the code ID. The full list of Defined and Undefined code categories is presented in **Appendix 1**.

Table 4 ICD-10-AM Place of Occurrence Codes

Description	**Code Blocks**
Place of Occurrence	Y920-Y929
Home	Y9209
Residential institution	Y9210-9
School, other institution and public administrative area	Y9221-9
Sports and athletic area	Y9230-9
Public highway, street or road	Y9240-9
Trade and service area	Y9250-9
Industrial and construction area	Y9260-9
Farm	Y927 & Y356-Y357

4.6.2.4 **Activity at Time of Injury Codes**

ICD-10-AM Activity codes contain details regarding the nature of activities that a person was undertaking at the time of injury. (**Table 5**) Out of a total of 276 codes, only eight (8; 3%) are described as Undefined. The full list of Defined and Undefined code categories is presented in **Appendix 1**.

Table 5 ICD-10-AM Activity at Time of Injury Codes

Description	Defined Code Blocks
Activity	U50-739
Sport and leisure	U50-72
Working for income	U7300-9
Other types of work	U731
Resting, sleeping, eating or other vital activities	U732

4.6.3 Haddon's Conformance and Information Quality

As previously described, each of the text descriptors associated with the 2,240 codes within ICD-10-AM external cause of injury chapter (Chapter XX) were analysed and broken down into components that describe the Host, Agent and Environment factors involved in the injury being coded. This categorisation was performed to enable examination of the nature of textual information and the coverage of key injury factors provided by ICD-10-AM codes. Due to the large number of individual codes and text descriptors within the ICD-10-AM code set, an example is presented following for each Haddon's element (Host; Agent; Environment). The full tables for all code blocks are presented in **Appendix 3**.

4.6.3.1 **Host**

4.6.3.1.1 Text Descriptors

The following table (Table 6) provides an example, presented by mechanism group, of the text descriptors present that convey Host information relating to an injury. Host information describes characteristics of the individual involved in the injury event (i.e. the patient).

For the majority of mechanisms, where present, the Host information is contained within the intent of the injury (i.e. assault, intentional self-harm). The mechanism block with the widest range of Host information is the Transport-related injury code block. In addition to describing the intent of the injury (i.e. whether the injury was self-inflicted or intentionally inflicted by another), these codes may contain information on the patient's position in the vehicle (e.g. driver, passenger, pedestrian) or the vehicle the patient was in at the time of injury (e.g. four wheel drive, motorcycle).

Table 6 ICD-10-AM – Example of Host Text Descriptors

MECHANISM	HOST TEXT DESCRIPTOR
Fall	Intentional self-harm
All Transport	intentional self-harm
	animal rider
	animal-rider or occupant of animal drawn vehicle
	any occupant (bus)
	driver (bus)
	driver (car)

4.6.3.1.2 Haddon's Matrix: All Codes and Intent Code Blocks

All codes were analysed for the presence or absence of Host information within the text code descriptor. These proportional breakdowns are displayed in the top row of **Table 7**. When all codes were examined together, across intent and mechanism blocks, four-fifths (82%) of codes contained at least one Host factor. However, there is variation evidenced in the proportions across intent blocks. Self-Harm and Assault codes have the highest proportions of codes with Host information present, due to the intent of the injury conveying host information (these are still reported in the interest of completeness), whilst the Undetermined intent code block contains no codes with any Host factors described.

Table 7 ICD-10-AM Codes by Host

HOST		All Intents		Unintentional		Self Harm		Assault		Undetermined	
	Haddon's	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
All Injury	Present	1845	82	1377	81	48	100	420	96	---	---
	Absent	395	18	326	19	---	---	20	5	49	100
	Total	**2240**	**100**	**1703**	**100**	**48**	**100**	**440**	**100**	**49**	**100**
Cut/Pierce	Present	67	86	1	17	6	100	60	100	---	---
	Absent	11	14	5	83	---	---	---	---	6	100
	Total	**78**	**100**	**6**	**100**	**6**	**100**	**60**	**100**	**6**	**100**
Drowning	Present	55	76	---	---	5	100	50	100	---	---
	Absent	17	24	12	100	---	---	---	---	5	100
	Total	**72**	**100**	**12**	**100**	**5**	**100**	**50**	**100**	**5**	**100**
Fall	Present	11	23	---	---	1	100	10	100	---	---
	Absent	36	77	35	100	---	---	---	---	1	100
	Total	**47**	**100**	**35**	**100**	**1**	**100**	**10**	**100**	**1**	**100**
Fire/hot object or substance	Present	22	43	---	---	2	100	20	100	---	---
	Absent	29	57	27	100	---	---	---	---	2	100
	Total	**51**	**100**	**27**	**100**	**2**	**100**	**20**	**100**	**2**	**100**
Firearm	Present	66	84	---	---	6	100	60	100	---	---
	Absent	13	17	6	100	---	---	---	---	7	100
	Total	**79**	**100**	**6**	**100**	**6**	**100**	**60**	**100**	**7**	**100**
Machinery	Present	---	---	---	---						
	Absent	20	100	20	100						
	Total	**20**	**100**	**20**	**100**						
All Transport	Present	1463	94	1375	94	8	100	80	100	---	---
	Absent	96	6	88	6	---	---	---	---	8	100
	Total	**1559**	**100**	**1463**	**100**	**8**	**100**	**80**	**100**	**8**	**100**
Natural/Environ mental	Present	---	---	---	---						
	Absent	80	100	80	100						
	Total	**80**	**100**	**80**	**100**						
Overexertion	Present	---	---	---	---						
	Absent	1	100	1	100						
	Total	**1**	**100**	**1**	**100**						
Poisoning	Present	74	73	---	---	14	100	60	100	---	---
	Absent	28	28	14	100	---	---	---	---	14	100
	Total	**102**	**100**	**14**	**100**	**14**	**100**	**60**	**100**	**14**	**100**
Struck by or against	Present	21	66	---	---	1	100	20	100	---	---
	Absent	11	34	10	100	---	---	---	---	1	100
	Total	**32**	**100**	**10**	**100**	**1**	**100**	**20**	**100**	**1**	**100**
Suffocation	Present	11	52	---	---	1	100	10	100	---	---
	Absent	10	48	9	100	---	---	---	---	1	100
	Total	**21**	**100**	**9**	**100**	**1**	**100**	**10**	**100**	**1**	**100**
Other Specified, Classifiable	Present	32	45	1	6	2	100	29	59	---	---
	Absent	39	55	17	94	---	---	20	41	2	100
	Total	**71**	**100**	**18**	**100**	**2**	**100**	**49**	**100**	**2**	**100**
Other Specified, nec	Present	12	86	---	---	1	100	11	100	---	---
	Absent	2	14	1	100	---	---	---	---	1	100
	Total	**14**	**100**	**1**	**100**	**1**	**100**	**11**	**100**	**1**	**100**
Unspecified	Present	11	85	---	---	1	100	10	100	---	---
	Absent	2	15	1	100	---	---	---	---	1	100
	Total	**13**	**100**	**1**	**100**	**1**	**100**	**10**	**100**	**1**	**100**

4.6.3.1.3 Haddon's Matrix: Mechanism Code Blocks

A further breakdown of the codes by mechanism of injury was performed. Again, variation is evident across code blocks, as displayed in the lefthand results column of **Table 7**. Transport codes have the highest proportion of Host information (94% Present). By comparison, all other Non-Transport codes have Host information for 56% of codes. Cut/Pierce and Firearm codes also contain a high proportion of Host information, with approximately four-fifths of codes within this block having host information present. However, Natural/Environmental, Overexertion and Machinery codes all contained no Host information. Fall codes are also very lacking, with less than one-quarter of all codes containing even one Host factor. Notably, the Other Specified (Not Elsewhere Classified) and Unspecified code blocks had relatively high proportions of Host factors available (86% and 85%, respectively).

When injury mechanism groups were examined for consistency across intents there was variation evident across intent blocks for some injury mechanisms. The Unintentional injury code block is markedly poorer than the other Intent blocks for all mechanisms except Transport. All mechanism blocks within Self Harm are well specified, with all codes containing at least one piece of Host information. Similarly on the whole, mechanism blocks within the Assault grouping contain Host information, the only exception being the Other Specified (Classifiable) group in which 41% of codes do not have Host information present. All mechanisms within the Undetermined group lack any Host information.

4.6.3.2 **Agent**

4.6.3.2.1 Text Descriptors

Table 8 presents an example of the text descriptors grouped by injury mechanism. As discussed previously, Agent information can be broken down into three subcomponents of Energy, Vector/Object, and Vehicle/Perpetrator, these are represented in separate columns of the table. The nature and number of descriptors available varies markedly by mechanism.

4.6.3.3 Agent - Energy

Table 9 examines the proportions of ICD-10-AM codes that contain information specifically regarding the Energy source of the injury.

4.6.3.3.1 Haddon's Matrix: Mechanism Code Blocks

Within the mechanism code blocks 'Unspecified' and 'Other Specified, Not Elsewhere Classified' codes display the lowest quality mechanism groups for Energy information (0% and 7% Present, respectively). 'Cut/Pierce' codes display only slightly improved quality with just 15% of codes containing details of the Energy source of the injury. Additionally, only one-third of the 'Struck by or against' codes contain any details of the Energy form of the injury. The 'All Transport' group is missing Energy information for approximately one-fifth of codes, and this information is not present for approximately one-tenth of the 'Natural / Environmental' mechanism group. All other mechanism groups were 100% present for Energy information.

Table 8 ICD-10-AM – Example Agent Text Descriptors

MECHANISM	AGENT TEXT DESCRIPTOR		
	Energy	**Vehicle/Object**	**Vector/Perpetrator**
Fall	kinetic (diving or jumping)	another person	acquaintance or friend
	kinetic (fall from, out of or through)	bed	carer
	kinetic (fall on and from)	building or structure	multiple persons unknown to victim
	kinetic (collision with or pushing)	chair	official authorities
	kinetic (slip)	cliff	other family member
	kinetic (stumble)	flying fox	Parent
	kinetic (trip)	ice-skates	person unknown to victim
	kinetic (fall)	ladder	spouse or domestic partner
	kinetic (jumping)	other furniture	
	kinetic (pushing)	other persons	
		Playground climbing apparatus	
		playground equipment	
		roller-skates	
		scaffolding	
		seesaw	
		skateboard	
		slide	
		snow board	
		snow ski	
		stairs and steps	
		swing	
		trampoline	
		tree	
		tree house	
		waterski	
		wheelchair	
All Transport	deprivation (drowning and submersion)	motor vehicles	
	kinetic (collision between)	agricultural vehicle	
	kinetic (collision with)	heavy vehicle	pedal cycle
	kinetic (crashing)	all-terrain 4wd	car
	kinetic (fall from or being thrown from)	all-terrain or other off-road motor vehicle	

4.6.3.3.2 Haddon's Matrix: All Codes and Intent Code Blocks

Overall, the proportion of codes containing Energy information (82%) is lower than that of all Agent information (99%). Assault-related codes contain the lowest proportion of Energy information (77% Present), whilst Undetermined intent codes contain the highest proportion (96%).

4.6.3.3.3 Haddon's Matrix: Mechanism by Intent Code Blocks

There is little variation evident across the code blocks in terms of the proportion of codes with Energy information present. Amongst the Unintentional injury code group, the mechanisms with the lowest proportions of Energy information are 'Unintentional; All Transport' (81% present) and 'Unintentional; Natural / Environmental' codes (91% present). Within the Self Harm and Assault intent blocks, 'Cut/Pierce', 'Struck by or against', and 'Unspecified' codes all contain no Energy information at all. In addition, 'Self Harm; Other Specified, Not elsewhere classified', 'Undetermined; Not elsewhere classified', and 'Undetermined; Unspecified' code groups also have 0% of Energy information present, whilst Energy information is present for 9% of 'Assault; Other Specified, Not elsewhere classified' codes. All other mechanism and intent groups have Energy information present for all codes.

Table 9 ICD-10-AM Codes by Energy

ENERGY	Haddon's	All Intents Frequency	All Intents %	Unintentional Frequency	Unintentional %	Self Harm Frequency	Self Harm %	Assault Frequency	Assault %	Undetermined Frequency	Undetermined %
All Injury	Present	1834	82	1408	83	39	81	340	77	47	96
	Absent	406	18	295	17	9	19	100	23	2	4
	Total	**2240**	**100**	**1703**	**100**	**48**	**100**	**440**	**100**	**49**	**100**
Cut/Pierce	Present	12	15	6	100	---	---	---	---	6	100
	Absent	66	85	---	---	6	100	60	100	---	---
	Total	**78**	**100**	**6**	**100**	**6**	**100**	**60**	**100**	**6**	**100**
Drowning	Present	72	100	12	100	5	100	50	100	5	100
	Absent	---	---	---	---	---	---	---	---	---	---
	Total	**72**	**100**	**12**	**100**	**5**	**100**	**50**	**100**	**5**	**100**
Fall	Present	47	100	35	100	1	100	10	100	1	100
	Absent	---	---	---	---	---	---	---	---	---	---
	Total	**47**	**100**	**35**	**100**	**1**	**100**	**10**	**100**	**1**	**100**
Fire/hot object or substance	Present	51	100	27	100	2	100	20	100	2	100
	Absent	---	---	---	---	---	---	---	---	---	---
	Total	**51**	**100**	**27**	**100**	**2**	**100**	**20**	**100**	**2**	**100**
Firearm	Present	79	100	6	100	6	100	60	100	7	100
	Absent	---	---	---	---	---	---	---	---	---	---
	Total	**79**	**100**	**6**	**100**	**6**	**100**	**60**	**100**	**7**	**100**
Machinery	Present	20	100	20	100						
	Absent	---	---	---	---						
	Total	**20**	**100**	**20**	**100**						
All Transport	Present	1273	82	1177	81	8	100	80	100	8	100
	Absent	286	18	286	20	---	---	---	---	---	---
	Total	**1559**	**100**	**1463**	**100**	**8**	**100**	**80**	**100**	**8**	**100**
Natural/Environmental	Present	73	91	73	91						
	Absent	7	9	7	9						
	Total	**80**	**100**	**80**	**100**						
Overexertion	Present	1	100	1	100						
	Absent	---	---	---	---						
	Total	**1**	**100**	**1**	**100**						
Poisoning	Present	102	100	14	100	14	100	60	100	14	100
	Absent	---	---	---	---	---	---	---	---	---	---
	Total	**102**	**100**	**14**	**100**	**14**	**100**	**60**	**100**	**14**	**100**
Struck by or against	Present	11	34	10	100	---	---	---	---	1	100
	Absent	21	66	---	---	1	100	20	100	---	---
	Total	**32**	**100**	**10**	**100**	**1**	**100**	**20**	**100**	**1**	**100**
Suffocation	Present	21	100	9	100	1	100	10	100	1	100
	Absent	---	---	---	---	---	---	---	---	---	---
	Total	**21**	**100**	**9**	**100**	**1**	**100**	**10**	**100**	**1**	**100**
Other Specified, Classifiable	Present	71	100	18	100	2	100	49	100	2	100
	Absent	---	---	---	---	---	---	---	---	---	---
	Total	**71**	**100**	**18**	**100**	**2**	**100**	**49**	**100**	**2**	**100**
Other Specified, nec	Present	1	7	1	100	---	---	1	9	---	---
	Absent	13	93	---	---	1	100	10	91	1	100
	Total	**14**	**100**	**1**	**100**	**1**	**100**	**11**	**100**	**1**	**100**
Unspecified	Present	---	---	1	100	---	---	---	---	---	---
	Absent	13	100	---	---	1	100	10	100	1	100
	Total	**13**	**100**	**1**	**100**	**1**	**100**	**10**	**100**	**1**	**100**

4.6.3.4 **Agent - Vehicle / Object**

The second aspect of the injury Agent, Vehicle/Object, details any animate object that was involved in the injury causation.

4.6.3.4.1 Haddon's Matrix: All Codes and Intent Blocks

Overall, detail of the injury vehicle is present for 93% of all codes. However, there is variability across the intent code blocks (top row of **Table 10**). Assault codes have the poorest information quality for Vehicle, with one-quarter of codes containing no Vehicle details. Comparatively, Vehicle information is present for four-fifths of Self harm and Undetermined Intent codes, and 98% of all Unintentional injury codes.

4.6.3.4.2 Haddon's Matrix: Mechanism Code Blocks

There was large variability evidenced in the proportion of codes with Vehicle/Object information present, by injury mechanism. The proportions vary across the mechanism categories from 0% to 100% (refer lefthand column of Table 10). 'Cut/Pierce', 'Drowning', 'Falls', 'Suffocation', 'Other Specified, Classifiable', 'Other Specified, Not elsewhere classifiable', and 'Unspecified' codes were all markedly low in the proportion of codes containing Vehicle/Object information.

Table 10 ICD-10-AM Codes by Vehicle/Object

VEHICLE/OBJECT		All Intents		Unintentional		Self Harm		Assault		Undetermined	
		n	%	n	%	n	%	n	%	n	%
All Injury	Present	2000	93	1589	98	40	83	330	75	41	84
	Not Present	159	7	33	2	8	17	110	25	8	16
	Total	**2159**	**100**	**1622**	**100**	**48**	**100**	**440**	**100**	**49**	**100**
Cut/Pierce	Present	54	69	6	100	4	67	40	67	4	67
	Not Present	24	31	---	---	2	33	20	33	2	33
	Total	**78**	**100**	**6**	**100**	**6**	**100**	**60**	**100**	**6**	**100**
Drowning	Present	46	64	10	83	3	60	30	60	3	60
	Not Present	26	36	2	17	2	40	20	40	2	40
	Total	**72**	**100**	**12**	**100**	**5**	**100**	**50**	**100**	**5**	**100**
Fall	Present	27	57	27	77	---	---	---	---	---	---
	Not Present	20	43	8	23	1	100	10	100	1	100
	Total	**47**	**100**	**35**	**100**	**1**	**100**	**10**	**100**	**1**	**100**
Fire/hot object or substance	Present	46	90	22	82	2	100	20	100	2	100
	Not Present	5	10	5	19	---	---	---	---	---	---
	Total	**51**	**100**	**27**	**100**	**2**	**100**	**20**	**100**	**2**	**100**
Firearm	Present	79	100	6	100	6	100	60	100	7	100
	Not Present	---	---	---	---						
	Total	**79**	**100**	**6**	**100**	**6**	**100**	**60**	**100**	**7**	**100**
Machinery	Present	20	100	20	100						
	Not Present	---	---	---	---						
	Total	**20**	**100**	**20**	**100**						
All Transport	Present	1552	99	1456	100	8	100	80	100	8	100
	Not Present	7	1	7	1	---	---	---	---	---	---
	Total	**1559**	**100**	**1463**	**100**	**8**	**100**	**80**	**100**	**8**	**100**
Natural/Environmental	Present										
	Not Present										
	Total										
Overexertion	Present										
	Not Present										
	Total										
Poisoning	Present	102	100	14	100	14	100	60	100	14	100
	Not Present	---	---	---	---	---	---	---	---	---	---
	Total	**102**	**100**	**14**	**100**	**14**	**100**	**60**	**100**	**14**	**100**
Struck by or against	Present	31	97	9	90	1	100	20	100	1	100
	Not Present	1	3	1	10	---	---	---	---	---	---
	Total	**32**	**100**	**10**	**100**	**1**	**100**	**20**	**100**	**1**	**100**
Suffocation	Present	3	14	3	33	---	---	---	---	---	---
	Not Present	18	86	6	67	1	100	10	100	1	100
	Total	**21**	**100**	**9**	**100**	**1**	**100**	**10**	**100**	**1**	**100**
Other Specified, Classifiable	Present	39	55	16	89	2	100	19	39	2	100
	Not Present	32	45	2	11	---	---	30	61	---	---
	Total	**71**	**100**	**18**	**100**	**2**	**100**	**49**	**100**	**2**	**100**
Other Specified, nec	Present	1	7	---	---	---	---	1	9	---	---
	Not Present	13	93	1	100	1	100	10	91	1	100
	Total	**14**	**100**	**1**	**100**	**1**	**100**	**19**	**39**	**1**	**100**
Unspecified	Present	---	---	---	---	---	---	---	---	---	---
	Not Present	13	100	1	100	1	100	10	100	1	100
	Total	**13**	**100**	**1**	**100**	**1**	**100**	**10**	**100**	**1**	**100**

4.6.3.5 **Mechanism by Intent Code Blocks**

When the injury mechanism blocks are examined by injury intent, 'Cut/Pierce', 'Drowning', 'Falls' and 'Suffocation', codes are lower for Self harm, Assault and Undetermined than the corresponding Unintentional injury codes. Additionally, the proportion of 'Other Specified, Classifiable', 'Other Specified, Not elsewhere classifiable and Unspecified' codes with Vehicle or Object information present are notably lower for Assault-related codes than for other intents.

4.6.3.6 **Agent - Vector / Perpetrator**

Vector and Perpetrator information is pertinent to certain injury mechanisms (i.e. Transport, Natural/Environmental, Overexertion, Suffocation and Assault). For Transport, Natural/Environmental, Overexertion and Suffocation mechanisms, Vector information details any animate objects that were involved in the injury causation. For assault codes, the vector refers to the person who inflicted the injury.

4.6.3.6.1 Haddon's Matrix: All Codes and Intent Code Blocks

Across all eligible code blocks, Vector or Perpetrator information was available for 92% of codes. In the case of assault codes, Perpetrator details are present for 80% of the codes.

4.6.3.6.2 Haddon's Matrix: Mechanism Code Blocks

For the majority of mechanism groups, Vehicle or Perpetrator information is available for four-fifths of codes within a block (**Table 11**). However, the proportion was higher for 'All Transport', 'Natural/Environmental', and 'Overexertion' codes blocks, and lower for 'Suffocation' codes.

Table 11 ICD-10-AM Codes by Vector/Perpetrator

VEHICLE/PERPETRATOR	Haddon's	All Intents n	All Intents %	Unintentional n	Unintentional %	Self Harm n	Self Harm %	Assault n	Assault %	Undetermined n	Undetermined %
All Injury	Present	1576	92	1208	96	8	100	352	80	8	100
	Absent	135	8	47	4	---	---	88	20	---	---
	Total	**1711**	**100**	**1255**	**100**	**8**	**100**	**440**	**100**	**8**	**100**
Cut/Pierce	Present	48	80					48	80		
	Absent	12	20					12	20		
	Total	**60**	**100**					**60**	**100**		
Drowning	Present	40	80					40	80		
	Absent	10	20					10	20		
	Total	**50**	**100**					**50**	**100**		
Fall	Present	8	80					8	80		
	Absent	2	20					2	20		
	Total	**10**	**100**					**10**	**100**		
Fire/hot object or substance	Present	16	80					16	80		
	Absent	4	20					4	20		
	Total	**20**	**100**					**20**	**100**		
Firearm	Present	48	80					48	80		
	Absent	12	20					12	20		
	Total	**60**	**100**					**60**	**100**		
Machinery	Present										
	Absent										
	Total										
All Transport	Present	1210	95	1130	96	8	100	64	80	8	100
	Absent	58	5	42	4	---	---	16	20	---	---
	Total	**1268**	**100**	**1172**	**100**	**8**	**100**	**80**	**100**	**8**	**100**
Natural/Environ mental	Present	77	96	77	96						
	Absent	3	4	3	4						
	Total	**80**	**100**	**80**	**100**						
Overexertion	Present	1	100	1	100						
	Absent	---	---	---	---						
	Total	**1**	**100**	**1**	**100**						
Poisoning	Present	48	80					48	80		
	Absent	12	20					12	20		
	Total	**60**	**100**					**60**	**100**		
Struck by or against	Present	16	80					16	80		
	Absent	4	20					4	20		
	Total	**20**	**100**					**20**	**100**		
Suffocation	Present	8	67	---	---			8	80		
	Absent	4	33	2	100			2	20		
	Total	**12**	**100**	**2**	**100**			**10**	**100**		
Other Specified, Classifiable	Present	39	80					39	80		
	Absent	10	20					10	20		
	Total	**49**	**100**					**49**	**100**		
Other Specified, nec	Present	9	82					9	82		
	Absent	2	18					2	18		
	Total	**11**	**100**					**11**	**100**		
Unspecified	Present	8	80					8	80		
	Absent	2	20					2	20		
	Total	**10**	**100**					**10**	**100**		

4.6.3.7 **Environment**

4.6.3.7.1 Text Descriptors

An example of the text descriptors available within ICD-10-AM external cause codes to describe the physical environmental conditions surrounding an injury event is displayed in **Table 12**, broken down by injury mechanism. (Note explanation given in Methods section 4.5.1 regarding primary external cause codes and place of occurrence codes).

4.6.3.7.1 Haddon's Matrix: All Codes and Intent Code Blocks

Overall, information regarding the Environment is present for 68% of all codes (**Table 13**). There is large variability across intent groups, with four-fifths of Unintentional codes having Environment information present, compared to only one-quarter to one-fifth for Self Harm, Assault and Undetermined intent code ranges.

4.6.3.7.2 Haddon's Matrix: Mechanism Code Blocks

Examining the presence of Environment information across mechanism code blocks, there is large variability. The 'All Transport' block contains the highest proportion of codes with environmental information (93%), compared to only 11% for the remaining non-transport related code blocks. Amongst the non-transport related mechanisms groups, 'Drowning' has the largest percentage of codes with Environment information present (64%), followed by 'Falls' at 43%. The remaining code blocks 'Cut/Pierce', 'Firearm', 'Machinery', 'Overexertion', 'Poisoning', 'Struck by or against', 'Other Specified, Classifiable', 'Other Specified, Not elsewhere classified', and 'Unspecified' are all absent for Environmental information.

Table 12 Environment Text Descriptors

Mechanism	Environment - Text Descriptor
Fall	high place
	from one level to another
	ice & snow
	water
	same level
	while being carried or supported by other persons
All Transport	air transport accident
	air transport accident (aircraft)
	nontraffic accident
	on-board watercraft
	traffic accident
	transport accident
	while boarding or alighting
	while boarding or alighting (aircraft)
	while boarding or alighting (special construction vehicle)
	while boarding or alighting from streetcar

Table 13 ICD-10-AM Codes by Environment

ENVIRONMENT	Haddon's	All Intents Frequency	All Intents %	Unintentional Frequency	Unintentional %	Self Harm Frequency	Self Harm %	Assault Frequency	Assault %	Undetermined Frequency	Undetermined %
All Injury	Present	1517	68	1374	81	11	23	120	27	12	25
	Absent	723	32	329	19	37	77	320	73	37	76
	Total	**2240**	**100**	**1703**	**100**	**48**	**100**	**440**	**100**	**49**	**100**
Cut/Pierce	Present	---	---	---	---	---	---	---	---	---	---
	Absent	78	100	6	100	6	100	60	100	6	100
	Total	**78**	**100**	**6**	**100**	**6**	**100**	**60**	**100**	**6**	**100**
Drowning	Present	46	64	10	83	3	60	30	60	3	60
	Absent	26	36	2	17	2	40	20	40	2	40
	Total	**72**	**100**	**12**	**100**	**5**	**100**	**50**	**100**	**5**	**100**
Fall	Present	20	43	9	26	---	---	10	100	1	100
	Absent	27	57	26	74	1	100	---	---	---	---
	Total	**47**	**100**	**35**	**100**	**1**	**100**	**10**	**100**	**1**	**100**
Fire/hot object or substance	Present	4	8	4	15	---	---	---	---	---	---
	Absent	47	92	23	85	2	100	20	100	2	100
	Total	**51**	**100**	**27**	**100**	**2**	**100**	**20**	**100**	**2**	**100**
Firearm	Present	---	---	---	---	---	---	---	---	---	---
	Absent	79	100	6	100	6	100	60	100	7	100
	Total	**79**	**100**	**6**	**100**	**6**	**100**	**60**	**100**	**7**	**100**
Machinery	Present	---	---	---	---						
	Absent	20	100	20	100						
	Total	**20**	**100**	**20**	**100**						
All Transport	Present	1444	93	1348	92	8	100	80	100	8	100
	Absent	115	7	115	8	---	---	---	---	---	---
	Total	**1559**	**100**	**1463**	**100**	**8**	**100**	**80**	**100**	**8**	**100**
Natural/Environ mental	Present	1	1	1	1						
	Absent	79	99	79	99						
	Total	**80**	**100**	**80**	**100**						
Overexertion	Present	---	---	---	---						
	Absent	1	100	1	100						
	Total	**1**	**100**	**1**	**100**						
Poisoning	Present	---	---	---	---	---	---	---	---	---	---
	Absent	102	100	14	100	14	100	60	100	14	100
	Total	**102**	**100**	**14**	**100**	**14**	**100**	**60**	**100**	**14**	**100**
Struck by or against	Present	---	---	---	---	---	---	---	---	---	---
	Absent	32	100	10	100	1	100	20	100	1	100
	Total	**32**	**100**	**10**	**100**	**1**	**100**	**20**	**100**	**1**	**100**
Suffocation	Present	2	10	2	22	---	---	---	---	---	---
	Absent	19	91	7	78	1	100	10	100	1	100
	Total	**21**	**100**	**9**	**100**	**1**	**100**	**10**	**100**	**1**	**100**
Other Specified, Classifiable	Present	---	---	---	---	---	---	---	---	---	---
	Absent	71	100	18	100	2	100	49	100	2	100
	Total	**71**	**100**	**18**	**100**	**2**	**100**	**49**	**100**	**2**	**100**
Other Specified, nec	Present	---	---	---	---	---	---	---	---	---	---
	Absent	14	100	1	100	1	100	11	100	1	100
	Total	**14**	**100**	**1**	**100**	**1**	**100**	**11**	**100**	**1**	**100**
Unspecified	Present	---	---	---	---	---	---	---	---	---	---
	Absent	13	100	1	100	1	100	10	100	1	100
	Total	**13**	**100**	**1**	**100**	**1**	**100**	**10**	**100**	**1**	**100**

4.6.3.8 **Place of Occurrence Codes**

ICD-10-AM Place of Occurrence codes relate to the physical environment surrounding an injury event, and as such should provide Environment information to inform Haddon's Matrix. When the 60 Place of Occurrence codes within ICD-10-AM were analysed according to the Haddon's Matrix framework only three codes (5%) were deemed to be absent of any useful information. These codes were, "Y92.8 Other specified place of occurrence", "Y92.88 Other specified place of occurrence", and "Y92.9 Unspecified place of occurrence".

4.6.3.9 **Activity at Time of Injury Codes**

ICD-10-AM Activity codes provide information regarding any activities a person was involved in at the time of injury, these code may therefore provide Host information to inform the Haddon's Matrix. When all 276 activity codes were examined for useful information for injury prevention purposes, only 3 (1%) codes were found to be 'Absent' of any useful details (U73 Other activity; U73.8 Other specified activity; U73.9 Unspecified activity).

4.6.4 Data Completeness Vs Information Quality Comparison

The concordance between Defined/Undefined code status and Haddon's Element Present/Absent status was calculated for each Haddon's Element (Host, Energy, Vehicle/Object, Vector/Perpetrator, Environment), by injury mechanism and intent code blocks. Full tables of comparisons within Intent and Mechanism code blocks are available in **Appendix 4**. Calculations of the completeness of coverage and specificity are presented by mechanism block.

4.6.4.1 **Host**

Overall agreement between Host Present status and Defined status is 80%. In total, Host element was present for 1,845 codes, whereas 2,065 codes were classified as Defined (see **Appendix 4** for complete table).

Table 14 presents the comparison of the "Defined/Undefined" data quality measure and the Haddon's Matrix information quality conceptualisation for Host element. Using the Haddon's Matrix conceptualisation as the comparator, the Defined/Undefined method of quality evaluation showed low levels of specificity (0 to 28%), and thus high false positive rates (72 to 100%) across all code blocks, with the exception of 'Other Specified, nec' and 'Unspecified'. Low specificity occurs where codes are categorised as Defined, but the codes do not contain pertinent Haddon's elements (Haddon's Absent).

Across all injury codes, the specificity of Defined/Undefined codes for Haddon's Host element was 14%, and completeness of coverage was 93%. Completeness of coverage level ranged from 0 to 100% across mechanism code blocks. The mechanism blocks of Machinery, Overexertion, Natural/Environmental, Other Specified nec and Unspecified codes demonstrated very low levels of completeness of coverage (0 to 8%). Low completeness of coverage occurs where the Defined/Undefined method of categorisation fails to identify as 'Defined' codes that the Haddon's conceptualisation denotes as being 'Haddon's Element Present'. Low completeness of coverage leads to high levels of false negatives, and a loss of available information.

Table 14 Data Completeness vs Information Quality: Host

HOST			Haddon's Element				
			Present	Absent	Total	Specificity	Coverage
All Injury	Usual	Defined	1725	340	2065		
		Undefined	120	55	175		
		Total	1845	395	2240	14%	93%
Cut/Pierce	Usual	Defined	45	9	54		
		Undefined	22	2	24		
		Total	67	11	78	18%	67%
Drowning	Usual	Defined	33	13	46		
		Undefined	22	4	26		
		Total	55	17	72	24%	60%
Fall	Usual	Defined	11	33	44		
		Undefined	0	3	3		
		Total	11	36	47	8%	100%
Fire/hot object or substance	Usual	Defined	22	26	48		
		Undefined	0	3	3		
		Total	22	29	51	10%	100%
Firearm	Usual	Defined	55	12	67		
		Undefined	11	1	12		
		Total	66	13	79	8%	83%
Machinery	Usual	Defined	0	20	20		
		Undefined	0	0	0		
		Total	0	20	20	0%	N/A
All Transport	Usual	Defined	1444	86	1530		
		Undefined	19	10	29		
		Total	1463	96	1559	10%	99%
Natural / Environmental	Usual	Defined	0	73	73		
		Undefined	0	7	7		
		Total	0	80	80	9%	N/A
Overexertion	Usual	Defined	0	1	1		
		Undefined	0	0	0		
		Total	0	1	1	0%	N/A
Poisoning	Usual	Defined	50	20	70		
		Undefined	24	8	32		
		Total	74	28	102	29%	68%
Struck by or against	Usual	Defined	21	11	32		
		Undefined	0	0	0		
		Total	21	11	32	0%	100%
Suffocation	Usual	Defined	11	8	19		
		Undefined	0	2	2		
		Total	11	10	21	20%	100%
Other Specified, Classifiable	Usual	Defined	32	28	60		
		Undefined	0	11	11		
		Total	32	39	71	28%	100%
Other Specified, nec	Usual	Defined	1	0	1		
		Undefined	11	2	13		
		Total	12	2	14	100%	8%
UnSpecified	Usual	Defined	0	0	0		
		Undefined	11	2	13		
		Total	11	2	13	100%	0%

4.6.4.2 **Agent**

4.6.4.2.1 Agent - Energy

Agreement between the Haddon's conceptualisation and Defined/Undefined status was 80% overall regarding the Energy source of the injury. The Haddon's conceptualisation classified 1834 codes to have Energy information present in the code descriptor, whilst the Defined/Undefined classification identified 2065 as being of a defined nature (see **Appendix 4** for complete table).

Overall specificity of Defined/Undefined categorisations for Haddon's Agent information was 16%, with a completeness of coverage of 94%. The specificity of the Defined/Undefined categorisations across mechanism groups was very low compared to the Haddon's Present/Absent groupings, with the majority of blocks ranging between 0 and 16%. (**Table 15**). This low level of specificity resulted in a high percentage of false positive results (67-100%) for a number of mechanism code groups (All injury; cut/pierce; All Transport; Natural environmental; Struck by or against). Completeness of coverage was higher, ranging between 64 and 100% for all mechanism blocks except 'Unspecified'.

Table 15 Data Completeness vs Information Quality: Energy

ENERGY			Haddon's Element				
			Present	Absent	Total	Specificity	Coverage
All Injury	Usual	Defined	1722	343	2065		
		Undefined	112	63	175		
		Total	1834	406	2240	16%	94%
Cut/Pierce	Usual	Defined	10	44	54		
		Undefined	2	22	24		
		Total	12	66	78	33%	83%
Drowning	Usual	Defined	46	0	46		
		Undefined	26	0	26		
		Total	72	0	72	N/A	64%
Fall	Usual	Defined	44	0	44		
		Undefined	3	0	3		
		Total	47	0	47	N/A	94%
Fire/hot object or substance	Usual	Defined	48	0	48		
		Undefined	3	0	3		
		Total	51	0	51	N/A	94%
Firearm	Usual	Defined	67	0	67		
		Undefined	12	0	12		
		Total	79	0	79	N/A	85%
Machinery	Usual	Defined	20	0	20		
		Undefined	0	0	0		
		Total	20	0	20	N/A	100%
All Transport	Usual	Defined	1258	272	1530		
		Undefined	15	14	29		
		Total	1273	286	1559	5%	99%
Natural / Environmental	Usual	Defined	67	6	73		
		Undefined	6	1	7		
		Total	73	7	80	14%	92%
Overexertion	Usual	Defined	1	0	1		
		Undefined	0	0	0		
		Total	1	0	1	N/A	100%
Poisoning	Usual	Defined	70	0	70		
		Undefined	32	0	32		
		Total	102	0	102	N/A	69%
Struck by or against	Usual	Defined	11	21	32		
		Undefined	0	0	0		
		Total	11	21	32	N/A	100%
Suffocation	Usual	Defined	19	0	19		
		Undefined	2	0	2		
		Total	21	0	21	N/A	90%
Other Specified, Classifiable	Usual	Defined	60	0	60		
		Undefined	11	0	11		
		Total	71	0	71	N/A	85%
Other Specified, nec	Usual	Defined	1	0	1		
		Undefined	0	13	13		
		Total	1	13	14	100%	100%
UnSpecified	Usual	Defined	0	0	0		
		Undefined	0	13	13		
		Total	0	13	13	100%	N/A

4.6.4.2.2 Agent - Vehicle/Object

Details of the injury Vehicle or Object involved had high overall agreement, with 94% of Haddon's Present/Absent classifications corresponding with the Defined/Undefined classification. The Vehicle or Object causing the injury was denoted in 2,000 of the ICD-10-AM codes, and a corresponding 1991 were determined to be Defined codes (see **Appendix 4** for complete Table).

For Vehicle/Object information the overall specificity of Defined/Undefined groupings was 61%, with 96% completeness of coverage. The specificity of Defined/Undefined groupings was 60% or higher for six of the mechanism code blocks (All injury, Cut/Pierce, Drowning, Fire/Hot object or substance, Other Specified nec and Unspecified) (**Table 16**). The remaining code blocks demonstrated lower specificity, ranging between 0 and 43%. Thus, there were high rates of false positives (57% or higher) amongst the Falls, Transport, Struck by or against, Suffocation and Other Specified Classifiable groups.

Comparatively, the completeness of coverage of the Defined codes for Vehicle/Object information was high for the majority of code blocks (96 to 100%). The exceptions were the mechanism blocks of Firearms (85%), Poisonings (69%) and Unspecified (0%).

Table 16 Data Completeness vs Information Quality: Vehicle/Object

VEHICLE/OBJECT			Haddon's Element				
			Present	Absent	Total	Specificity	Coverage
All Injury	Usual	Defined	1929	62	1991		
		Undefined	71	97	168		
		Total	2000	159	2159	61%	96%
Cut/Pierce	Usual	Defined	54	0	54		
		Undefined	0	24	24		
		Total	54	24	78	100%	100%
Drowning	Usual	Defined	46	0	46		
		Undefined	0	26	26		
		Total	46	26	72	100%	100%
Fall	Usual	Defined	27	17	44		
		Undefined	0	3	3		
		Total	27	20	47	15%	100%
Fire/hot object or substance	Usual	Defined	46	2	48		
		Undefined	0	3	3		
		Total	46	5	51	60%	100%
Firearm	Usual	Defined	67	0	67		
		Undefined	12	0	12		
		Total	79	0	79	N/A	85%
Machinery	Usual	Defined	20	0	20		
		Undefined	0	0	0		
		Total	20	0	20	N/A	100%
All Transport	Usual	Defined	1526	4	1530		
		Undefined	26	3	29		
		Total	1552	7	1559	43%	98%
Natural / Environmental	Usual	Defined					
		Undefined					
		Total					
Overexertion	Usual	Defined					
		Undefined					
		Total					
Poisoning	Usual	Defined	70	0	70		
		Undefined	32	0	32		
		Total	102	0	102	N/A	69%
Struck by or against	Usual	Defined	31	1	32		
		Undefined	0	0	0		
		Total	31	1	32	0%	100%
Suffocation	Usual	Defined	3	16	19		
		Undefined	0	2	2		
		Total	3	18	21	11%	100%
Other Specified, Classifiable	Usual	Defined	38	22	60		
		Undefined	1	10	11		
		Total	39	32	71	31%	97%
Other Specified, nec	Usual	Defined	1	0	1		
		Undefined	0	13	13		
		Total	1	13	14	100%	100%
UnSpecified	Usual	Defined	0	0	0		
		Undefined	0	13	13		
		Total	0	13	13	100%	N/A

4.6.4.2.3 Agent - Vector/Perpetrator

Concordance between Vector or Perpetrator detail presence and Defined quality of the data was acceptable overall (88%). Vector or Perpetrator details, (dependent upon the intent of the injury), were present for 1,576 codes, whereas slightly more codes (n= 1,587) were classified as Defined. It must be noted that some mechanisms have small (or no) cell numbers as Vector or Perpetrator elements are not pertinent for all code blocks (see **Appendix 4** for complete table).

Specificity of the Defined/Undefined code groupings was low (18%) for Vector/Perpetrator information across the code blocks. (**Table 17**) Only three code blocks demonstrated a specificity greater of 67% or greater (Natural/Environmental = 67%; Other Specified nec & Unspecified = 100%), Suffocation had a specificity of 50%. All other mechanism had high false positive percents, ranging between 67% and 100%. Completeness of coverage of the Defined/Undefined groupings for Vector/Perpetrator was 94% overall, and ranged between 60% and 100% for the majority of code blocks.

Table 17 Data Completeness vs Information Quality: Vector/Perpetrator

VECTOR/PERPETRATOR			Haddon's Element				
			Present	Absent	Total	Specificity	Coverage
All Injury	Usual	Defined	1476	111	1587		
		Undefined	100	24	124		
		Total	1576	135	1711	18%	94%
Cut/Pierce	Usual	Defined	32	8	40		
		Undefined	16	4	20		
		Total	48	12	60	33%	67%
Drowning	Usual	Defined	24	6	30		
		Undefined	16	4	20		
		Total	40	10	50	40%	60%
Fall	Usual	Defined	8	2	10		
		Undefined	0	0	0		
		Total	8	2	10	0%	100%
Fire/hot object or substance	Usual	Defined	16	4	20		
		Undefined	0	0	0		
		Total	16	4	20	0%	100%
Firearm	Usual	Defined	40	10	50		
		Undefined	8	2	10		
		Total	48	12	60	17%	83%
Machinery	Usual	Defined					
		Undefined					
		Total					
All Transport	Usual	Defined	1195	58	1253		
		Undefined	15	0	15		
		Total	1210	58	1268	0%	99%
Natural / Environmental	Usual	Defined	72	1	73		
		Undefined	5	2	7		
		Total	77	3	80	67%	94%
Overexertion	Usual	Defined	1	0	1		
		Undefined	0	0	0		
		Total	1	0	1	N/A	100%
Poisoning	Usual	Defined	32	8	40		
		Undefined	16	4	20		
		Total	48	12	60	33%	67%
Struck by or against	Usual	Defined	16	4	20		
		Undefined	0	0	0		
		Total	16	4	20	0%	100%
Suffocation	Usual	Defined	8	2	10		
		Undefined	0	2	2		
		Total	8	4	12	50%	100%
Other Specified, Classifiable	Usual	Defined	31	8	39		
		Undefined	8	2	10		
		Total	39	10	49	20%	79%
Other Specified, nec	Usual	Defined	1	0	1		
		Undefined	8	2	10		
		Total	9	2	11	100%	11%
UnSpecified	Usual	Defined	0	0	0		
		Undefined	8	2	10		
		Total	8	2	10	100%	0%

4.6.4.3 **Environment**

Finally, agreement overall was lowest for the element of Environment. Across all codes, overall concordance between Haddon's and the 'Traditional Defined/Undefined' measure of quality was 74%. The Defined categorisation schema denoted more codes as being of higher quality Defined codes (n= 2,065), than did the Haddon's system categorise as containing Environment information (n = 1,517) (see **Appendix 4** for complete Table).

The specificity of Defined group assignments for Environment information was low across all code blocks (21% overall). (**Table 18**) Drowning, Other Specified nec and Unspecified code blocks had the highest level of specificity (93-100%). In comparison, Fall, Fire/Hot object or substance, Firearm, Machinery, All Transport, Natural/Environmental, Overexertion, Struck by or against, Suffocation, and Other Specified Classifiable code blocks all displayed specificity levels of 15% or lower, and consequently false positive levels of 69% or higher. Completeness of coverage was high (98-100%) for all mechanism code blocks where it could be calculated.

Table 18 Data Completeness vs Information Quality: Environment

ENVIRONMENT			Haddon's Element				
			Present	Absent	Total	Specificity	Coverage
All Injury	Usual	Defined	1494	571	2065		
		Undefined	23	152	175		
		Total	1517	723	2240	21%	98%
Cut/Pierce	Usual	Defined	0	54	54		
		Undefined	0	24	24		
		Total	0	78	78	31%	N/A
Drowning	Usual	Defined	46	0	46		
		Undefined	0	26	26		
		Total	46	26	72	100%	100%
Fall	Usual	Defined	18	26	44		
		Undefined	2	1	3		
		Total	20	27	47	4%	90%
Fire/hot object or substance	Usual	Defined	4	44	48		
		Undefined	0	3	3		
		Total	4	47	51	6%	100%
Firearm	Usual	Defined	0	67	67		
		Undefined	0	12	12		
		Total	0	79	79	15%	N/A
Machinery	Usual	Defined	0	20	20		
		Undefined	0	0	0		
		Total	0	20	20	0%	N/A
All Transport	Usual	Defined	1423	107	1530		
		Undefined	21	8	29		
		Total	1444	115	1559	7%	99%
Natural / Environmental	Usual	Defined	1	72	73		
		Undefined	0	7	7		
		Total	1	79	80	9%	100%
Overexertion	Usual	Defined	0	1	1		
		Undefined	0	0	0		
		Total	0	1	1	0%	N/A
Poisoning	Usual	Defined	0	70	70		
		Undefined	0	32	32		
		Total	0	102	102	31%	N/A
Struck by or against	Usual	Defined	0	32	32		
		Undefined	0	0	0		
		Total	0	32	32	0%	N/A
Suffocation	Usual	Defined	2	17	19		
		Undefined	0	2	2		
		Total	2	19	21	11%	100%
Other Specified, Classifiable	Usual	Defined	0	60	60		
		Undefined	0	11	11		
		Total	0	71	71	15%	N/A
Other Specified, nec	Usual	Defined	0	1	1		
		Undefined	0	13	13		
		Total	0	14	14	93%	N/A
UnSpecified	Usual	Defined	0	0	0		
		Undefined	0	13	13		
		Total	0	13	13	100%	N/A

4.6.5 Summary of Study 1 Results

Across all injury intents and mechanisms, the prevalence of "Defined" codes, using the 'traditional' Defined/Undefined measure of data completeness, was 92%. The lowest rate of Defined codes was evidenced within the Self Harm intent block (69% Defined), and the highest amongst Unintentional intent injury codes (97%). Examining the distribution of Defined codes by injury mechanism showed the highest percentage to be within the 'All-Transport' mechanism (98%). Additionally, of the 60 available Place of Occurrence Codes, 60% were classified as Defined, and 97% of the 276 Activity codes were Defined.

Examination of the ICD-10-AM external cause of injury code set by Haddon's injury elements showed variation by injury information element (e.g. Host, Energy, etc.) and intent grouping, as summarised below in **Table 19**. The injury element with the poorest information quality was that of Environment, which was absent from 32% of all codes collectively, and from approximately three-quarters of Self-Harm, Assault and Undetermined Intent injuries. Whilst there was marked variability in the rate of present Haddon's elements across the various code groups, there was no systematic variation by intent and mechanism.

Table 19 Summary of Haddon's Elements by Injury Intent

ALL INJURIES	HADDON'S ELEMENT	All Intents n	All Intents %	Unintentional n	Unintentional %	Self-Harm n	Self-Harm %	Assault n	Assault %	Undetermined n	Undetermined %
HOST	Present	1845	82	1377	81	48	100	420	96	---	---
	Absent	395	18	326	19	---	---	20	5	49	100
	Total	**2240**	**100**	**1703**	**100**	**48**	**100**	**440**	**100**	**49**	**100**
ENERGY	Present	1834	82	1408	83	39	81	340	77	47	96
	Absent	406	18	295	17	9	19	100	23	2	4
	Total	**2240**	**100**	**1703**	**100**	**48**	**100**	**440**	**100**	**49**	**100**
VEHCLE / OBJECT	Present	2000	93	1589	98	40	83	330	75	41	84
	Not Present	159	7	33	2	8	17	110	25	8	16
	Total	**2159**	**100**	**1622**	**100**	**48**	**100**	**440**	**100**	**49**	**100**
VECTOR / PERPETRATOR	Present	1576	92	1208	96	8	100	352	80	8	100
	Absent	135	8	47	4	---	---	88	20	---	---
	Total	**1711**	**100**	**1255**	**100**	**8**	**100**	**440**	**100**	**8**	**100**
ENVIRONMENT	Present	1517	68	1374	81	11	23	120	27	12	25
	Absent	723	32	329	19	37	77	320	73	37	76
	Total	**2240**	**100**	**1703**	**100**	**48**	**100**	**440**	**100**	**49**	**100**

A summary of the concordance between the ‘traditional’ Defined/Undefined data completeness measure and the novel Haddon’s matrix conceptualisation of information quality is presented in **Table 20**. The displayed results are summarised across all injury intent and mechanism blocks. Using the Haddon’s conceptualisation as the comparator, the Defined/Undefined measure demonstrates a Completeness of Coverage (proxy sensitivity) in excess of 90% across all injury elements. Specificity of the Defined/Undefined measure is low for Vehicle/Object (61%), and very low across the other injury elements (<=21%).

Table 20 Data Completeness vs Haddon's Information Quality - All Injuries

ALL INJURIES			Haddon's Element				
			Present	Absent	Total	Specificity	Complete-ness
HOST	**Usual**	Defined	1725	340	2065		
		Undefined	120	55	175		
		Total	1845	395	2240	14%	93%
ENERGY	**Usual**	Defined	1722	343	2065		
		Undefined	112	63	175		
		Total	1834	406	2240	16%	94%
VEHICLE / OBJECT	**Usual**	Defined	1929	62	1991		
		Undefined	71	97	168		
		Total	2000	159	2159	61%	96%
VECTOR / PERPETRATOR	**Usual**	Defined	1476	111	1587		
		Undefined	100	24	124		
		Total	1576	135	1711	18%	94%
ENVIRONMENT	**Usual**	Defined	1494	571	2065		
		Undefined	23	152	175		
		Total	1517	723	2240	21%	98%

Separate examination of two key injury areas, Transport and Falls –related events, are presented. (**Tables 21** and **22**, respectively) Both demonstrate high levels of completeness of coverage (94-100%) for the Defined/Undefined measure of data completeness across all Haddon's elements, indicating that for these injury mechanism groups the Defined/Undefined measure of data quality is responsive to identifying the presence of this information. However, the Defined/Undefined measure of data quality is lacking in specificity, ranging between 0 and 15% for all elements with the exception of All Transport - Vehicle/Object (43%). Low levels of specificity result in an overinflated measure of data quality as described by this measure. Many codes are inaccurately designated as "Defined", as they do not contain the terms "Other specified" or "Unspecified", however when evaluated against Haddon's elements these codes do not prove to contain relevant injury information.

Table 21 Data Completeness vs Haddon's Information Quality - Transport

All Transport			Haddon's Element				
			Present	Absent	Total	Specificity	Complete-ness
Host	Usual	Defined	1444	86	1530		
		Undefined	19	10	29		
		Total	1463	96	1559	10%	99%
Energy	Usual	Defined	1258	272	1530		
		Undefined	15	14	29		
		Total	1273	286	1559	5%	99%
Vehicle/ Object	Usual	Defined	1526	4	1530		
		Undefined	26	3	29		
		Total	1552	7	1559	43%	98%
Vector/ Perpetrator	Usual	Defined	1195	58	1253		
		Undefined	15	0	15		
		Total	1210	58	1268	0%	99%
Environment	Usual	Defined	1423	107	1530		
		Undefined	21	8	29		
		Total	1444	115	1559	7%	99%

Table 22 Data Completeness vs Haddon's Information Quality - Falls

Falls			Haddon's Element				
			Present	Absent	Total	Specificity	Complete-ness
Host	Usual	Defined	11	33	44		
		Undefined	0	3	3		
		Total	11	36	47	8%	100%
Energy	Usual	Defined	44	0	44		
		Undefined	3	0	3		
		Total	47	0	47	N/A	94%
Vehicle/ Object	Usual	Defined	27	17	44		
		Undefined	0	3	3		
		Total	27	20	47	15%	100%
Vector/ Perpetrator	Usual	Defined	8	2	10		
		Undefined	0	0	0		
		Total	8	2	10	0%	100%
Environment	Usual	Defined	18	26	44		
		Undefined	2	1	3		
		Total	20	27	47	4%	90%

4.7 *Discussion*

The purpose of this study was to describe ICD-10-AM external cause of injury codes in terms of their provision of cause of injury information; and to compare the Completeness of Coverage and Specificity of the 'traditional' view of data completeness to the proposed Haddon's conceptualisation of information quality. The ICD-10-AM code system is skewed towards the description of Unintentional injuries, with three-quarters of the codes contained within this intent block. Likewise, the code system is heavily weighted towards the detailed capture of transport-related mechanism of injury, with a similar proportion of all codes within this block; by comparison, Falls codes comprised only 2% of the code system.

4.7.1 Traditional "Defined/Undefined" Measure of 'Data Completeness'

Two research questions related to the description of the underlying ICD-10-AM external cause of injury code system using the 'traditional' Defined/Undefined method of assessing data completeness:

a. What percentage of codes are 'Undefined' (poor data completeness) within the ICD-10-AM external cause of injury code set? And

b. Does the proportion of 'Undefined' codes vary by injury mechanism and intent?

Despite criticisms in the literature of the lack of precision, or detail, of ICD codes for injury research, overall 92% of codes within ICD-10-AM Chapter XX were classified as 'Defined'. This indicates that only 8% of the total 2,240 codes examined were classified as being of being poor data quality using this measure. This result suggests that categorisation of code quality by the presence of "Other specified" or "Unspecified" in the text descriptor, or a terminal code digit of .8 or .9, is an insensitive measure that does not reflect the users' needs of the data in this conceptualisation of quality.

There was variation evidenced across the injury mechanism code blocks in terms of proportion of defined versus undefined codes. The code blocks with the highest prevalence of Undefined codes, and thereby the lowest data quality, were 'Fire/Hot object or substance (45% undefined); Drowning (36% undefined); Cut/Pierce & Poisoning (both 31% undefined); and Other Specified (29% undefined). No systematic variation in data completeness was evident by intent and mechanism code block.

Whilst the Activity codes demonstrated high data completeness, by this measure, it is not possible to evaluate them effectively as this information is contained as separate, optional, code in addition to the main external cause of injury code. It is arguable that the most likely threat to data quality with these codes is compliance with assigning them to cases. As this analysis is of the underlying code system only it is not possible in this study to measure this aspect of the data completeness. The same applies to Place of Occurrence codes, however, they also displayed lower data completeness than Activity codes, with only 60% of codes being categorised as Defined. There is a lack of code options in this part of the codes set, with too few categories (i.e. two options available to code an injury at a private residence, either 'in the home' or 'in the driveway').

In addition, the Defined/Undefined categorisation doesn't take into account where multiple elements of information are contained within pre-coordinated ICD codes (i.e. a single code can contain some or all of intent, mechanism, host, agent and environment element of injury information). Thus, whilst this method of defining data quality leads to an largely positive assessment of overall data completeness, this broad designation ("Defined/Undefined") obscures the multiple pieces of information that may each be either present or absent. This measure of 'quality' is too granular a determination for the complex code structure of ICD-10-AM codes. There is need for a framework to more systematically evaluate the information quality of ICD-10-AM external cause of injury codes.

4.7.1.1 **Haddon’s Matrix Conceptualisation of ‘Information Quality’**

Two research questions in this study related to the testing of the Haddon’s matrix framework conceptualisation of information quality:

a. What percentages of codes contain information that relates to each of the Haddon’s injury elements (Host, Agent, Environment)? and

b. Does the percentage differ by injury mechanism and intent?

This study establishes the feasibility of deconstructing the ICD-10-AM external cause codes into constituent Haddon’s elements. Once the ICD-10-AM code descriptors were parsed into their component terms, it was evident that there is large variability in the quantity and nature of text descriptors by mechanism, intent and Haddon’s injury element. High information quality was evident across the code system for the elements of Agent and Host. However, many of these codes are self-definitional as often the intent or mechanism description contains the host or agent information (e.g. Assault by bodily force, person unknown to the victim; Assault = was victim of unlawful act [host information]). In terms of injury mechanism groups, Transport codes demonstrated the highest proportions of ‘Present’ items across all Haddon’s elements. This seems appropriate given that the Transport section of the of the code system is the most highly developed, containing 70% of the entire ICD-10-AM Chapter XX code set. This also perhaps reflects the high profile of transport-related research, and the amount of attention that has already been placed on the development of data to inform this sector of injury research.

Environment had lowest coverage, with only 68% of all codes (i.e. all injury mechanisms) containing any information regarding the physical environment in which the injury occurred. Environment was most prevalent in the All Transport code section (93% present). This is attributable to a large proportion of Transport codes containing information relating to whether it was a "Traffic" or "Non-Traffic" crash, which implies information regarding the environment (i.e. roadway or off-road). Notably, only 11% of Non-transport codes contained Environment information.

Haddon's matrix provided a functional and systematic framework by which to dissect the ICD-10-AM codes into discrete, more manageable segment of information that better reflect the multidimensional nature of these codes. This enables more thorough evaluation of the coverage of key injury concepts, to ensure that the codes are structured to collect quality information key aspects of an injury event that are vital for the identification and design of prevention strategies.

Whilst place of occurrence codes used in tandem with primary external cause of injury codes may provide more useful environment information, this was not able to be evaluated in this study given the independent application of these codes from the main external cause of injury code in the ICD-10-AM.

4.7.1.2 **Comparison of Data Quality and Information Quality**

The proposed Haddon's Matrix conceptualisation has been established to be a feasible framework for examining the structure of ICD-10-AM codes. In order to establish this method as a viable operational definition of information quality, comparison with the established method of categorising codes as Defined/Undefined is required. Three stated research questions related to this objective:

a. To what degree does the traditional 'Defined/Undefined' view of quality over- or under-estimate ICD-10-AM code quality compared to the Haddon's matrix model?

b. Does the Haddon's Matrix conceptualisation provide a more comprehensive coverage and a more specific measure of code quality than the 'traditional' Defined/Undefined categorisation?

c. Is there any difference by injury mechanism and intent?

Whilst there was variation across individual cells in **Tables 14-18** in terms of both Completeness of Coverage and Specificity, overall Completeness of coverage (a proxy measure of sensitivity) was high (>90%) across all codes for each of the Haddon's elements (**Table 20**). This indicates high levels of agreement between the Haddon's element categorisation (i.e. Present/Absent) and the 'traditional' Defined/Undefined in detecting true positive cases (i.e. where Haddon's element is recorded as 'Present', traditional method is recorded as 'Defined'). However, this is evidently due to an over-estimation of data quality that is inherent in the Defined/Undefined categorisation model, as demonstrated by high false positive rates. The highest specificity level for the Defined/Undefined quality measure was the Vehicle/Object element (61%), though this is largely attributable to the Transport code block (93% specificity) where Vehicle information was largely available. Other mechanism blocks had much lower specificity levels. The remaining Haddon's elements (Host, Energy, Vector and Environment) had much lower specificity levels for the Defined/Undefined measure (21% or less). The low specificity levels indicate a high rate of false positives (i.e. code is classified as "Defined" when Haddon's injury element is Absent) associated with the Defined/Undefined data measure. Thus, for the Host, Energy, Vector and Environment elements, across all codes, the Defined/Undefined method overestimates data completeness in excess of 80% of codes.

All transport codes had low specificity (ranging between 0% and 43%); given that transport codes are the most structured in the ICD-10-AM code system, this low specificity of the Defined/Undefined categorisation demonstrates the constraint of this evaluation method. The 'traditional' evaluation of ICD data quality over-categorises codes as being of a 'Defined' nature, or high degree of data completeness. This method of evaluation is based upon explicit statements identifying an undefined aspect to the code (i.e. "Other Specified" or "Unspecified" in the code descriptor, or a .8 or .9 terminal digit). If no explicit "undefined" aspect is identified, the code is defaulted to a "Defined" status. There is no mechanism by which to identify whether important information elements are simply omitted. Evaluating codes in this manner lacks the precision required to accurately discern between a code that contains an aspect of 'nondefined' data in combination with multiple other specific aspects (this code would be designated as Undefined due to the one piece of explicitly stated undefined information), and a code with sparse but defined information. Under the conventional means of assessing code quality the sparse, but technically, "fully defined" code would be evaluated to be of higher quality than the code that contains multiple elements of pertinent injury information, one of which has been denoted as "Other or Unspecified".

Whilst the Defined/Undefined categorisations achieve a completeness of coverage (proxy sensitivity measure) in the region of 80 to 100% across Haddon's elements for many injury mechanisms, in the majority of cases these are accompanied by equally high False Positive rates. Any categorisation system could achieve a sensitivity (or completeness of coverage) level of 100% if it were to blankly assign all cases to a single category, however this does not mean that the category assignment is accurate, but merely comprehensive. Consequently, the resultant codes contribute little information of a specific or reliable nature.

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Haddon's Matrix and injury prevention are public health, and specifically epidemiological, activities. The utilisation of this proposed Haddon's framework for injury data evaluation grounds classification development in a public health framework, and enables the use of epidemiological analysis methods (i.e. completeness of coverage, specificity, false positive, false negatives) to conduct more rigorous evaluations of code and classification system structure. This study has demonstrated this novel approach to quantifying information quality of injury data to have comparable completeness of coverage to the traditional Defined/Undefined method of measuring data completeness. However, the Defined/Undefined measure exhibits far inferior levels of specificity, and hence increased false positive rates [1-Specificity]. Consequently, the Defined/Undefined method of conceptualising data quality leads to elevated, and misleading, estimates as to the value of resultant data. It is asserted that the Haddon's matrix conceptualisation of information quality, which has been grounded in relevant injury theory, should be used in preference as a more accurate measure of the quality of injury data.

4.7.1.3 **Priority Areas for Improvement**

The final research question posed by this study was:

> Can high priority code blocks for quality improvement be identified, due to a high prevalence of absent Haddon's elements (Host, Agent, Environment information)?

The presence of Haddon's elements varied across the injury mechanism blocks, with few consistent patterns. Results of this study demonstrate that ICD-10-AM codes can systematically collect information regarding Host, Agent and Environment aspects of an injury. However, completeness of coverage of these elements is inconsistent across code blocks, indicating need for further development work in this area. The most marked area in need of improvement is the Environment element, where ICD-10-AM codes showed low levels of available information. Hence, the approach of assigning place of occurrence codes in tandem with external cause codes is a practice that should remain mandatory to ensure the critical information is not degraded.

4.7.1.4 **Study Limitations**

This study represents a proof of concept investigation to evaluate the applicability of a 'fit-for-purpose' measure of current ICD-10-AM external cause classification structure for injury prevention research by utilising the Haddon's Matrix framework. As such, a liberal approach was intentionally applied to the categorisation of Haddon's element Present/Absent. The presence of information relating to any/all of these factors was not evaluated for subjective quality but rather categorised on a dichotomised Present/Absent basis. Some text descriptors may be more or less informative than others. Evaluating the relative value of an individual text descriptor is subjective (depending upon the injury mechanism and the study of interest), and is outside the scope of this project, requiring content specific experts to evaluate the individual mechanism blocks.

Some cells displayed in the results tables have very small numbers (<5). This study was examining the characteristics of the underlying ICD-10-AM code system. Given the structure of this classification system some specific mechanisms contain very few codes options (e.g. Overextertion, Struck by or Against – Self-harm). The occurrence of small cell numbers can result in exaggerated percentages.

The comprehensive assessment of the information quality of Place of Occurrence codes and Environment information is complicated in ICD-10-AM. Place of occurrence codes are separate items that are used in accompaniment with the main external cause of injury. Both the place code and the external cause code can contain information that pertains to environmental information; however there are vast arrays of possible code combinations that may be assigned making it impossible to consolidate this information for this assessment. As a result, environmental information within the external cause codes and the place of occurrence codes has been considered separately in this study. This may result in an underestimation of the total environmental information contained within the ICD-10-AM code system. However, as place of occurrence code assignment is inconsistent internationally, and established in the literature to be problematic, the impact of this is argued to be small.

4.7.1.5 Issues for Further Investigation

These results provide information regarding the distribution and information quality of available codes within the underlying ICD-10-AM external cause of injury code system. This study was conducted to evaluate the information quality of the available code system, uncontaminated by the impacts of other factors that impact upon coded data quality, such as coder error or documentation sufficiency. This analysis provides a benchmark of the overall code system characteristics and identifies theoretical areas for improvement based upon poor coverage of concept or specificity of code categories.

The next extension of this research is to examine the code system in application to explore how this fundamental coding structure translates to practice (i.e. Hospital coded data). Does the theoretical code system quality translate directly to the coded datasets? In order to identify high priority areas for development, there is a need to evaluate the proportional utilisation of high and low information quality codes within the coded injury dataset. Are poor information quality codes overutilised in the hospital coding process, or do coders preferentially select codes with a higher information value? Identification of frequently assigned codes is important for informing and prioritising data development activities.

In addition, where poor information quality codes are utilised in the hospital dataset, there is a need to evaluate the reasons for this code assignment in order to identify the most appropriate remediation. Is it due to a lack of other more detailed code options, due to coder error or apathy in code assignment, or because of a lack of detailed information within the source documentation?

CHAPTER 5. ICD-10-AM IN CONTEXT - QLD HOSPITAL MORBIDITY DATA (Study2)

5.1 *Background*

The Study 1 results established the utility of the Haddon's matrix framework for defining and measuring information quality of injury data. The novel Haddon's matrix conceptualisation was contrasted with the established measure of ICD data quality, based on a crude data completeness measure. This proposed measure demonstrated equivalent completeness of coverage to the current data completeness (Defined/Undefined code status). Importantly, the Defined/Undefined method of evaluation of data quality demonstrated inferior levels of specificity. The Defined/Undefined code categorisations resulted in an inflated assessment of ICD-10-AM code system quality that does not correspond with the reported limitations of this coding system.

The purpose of this chapter (Study 2) is to utilise the proposed Haddon's matrix 'fit-for-purpose' measure to conduct an evaluation of the information quality of ICD-10-AM coded external cause of injury codes 'in action'. The ICD-10-AM coded Queensland Hospital morbidity dataset, a potentially valuable resource for injury research, will be evaluated using the Haddon's matrix information quality measure to evaluate the overall fit-for-purpose of this dataset for the intended purpose of injury prevention research (**Figure 13**).

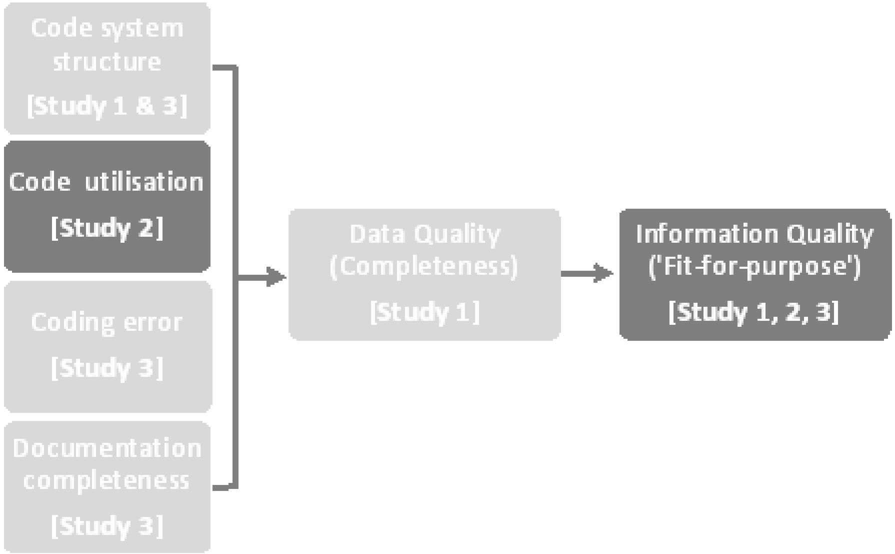

Figure 12 Study 2 Contribution

5.2 *Key Objectives*

The key objectives of this study are to provide a descriptive analysis of Queensland Hospital Morbidity data to:

1. evaluate the 'fit-for-purpose' information quality of ICD-10-AM codes in context, by employing the proposed Haddon's matrix framework; and

2. identify priority areas for quality improvement, based upon high frequency codes blocks with low information quality.

5.3 *Research Questions*

The specific research questions for this study are:

1. What is the 'information quality' of the Queensland hospital morbidity dataset for injury research?

2. Does the information quality vary by injury mechanism and intent?

3. What are the relative utilisation rates within the hospital morbidity dataset of ‘poor’ information quality codes, identified in Study 1?

4. Can high priority code blocks for quality improvement be identified due to either a high prevalence or overutilisation of codes with ‘Absent’ Haddon’s elements (Host, Agent, Environment information)?

5.4 *Method*

5.4.1 Ethical Clearance

Ethical clearance for this study was obtained from the Queensland University of Technology Human Research Ethics Committee. Ethical review determined that the study design was outside the scope of ethics arrangements due to the use of de-identified data only (QUT Ref No 3874H).

5.4.2 Study Design and Setting

This study involved a quantitative analysis of a routinely collected retrospective statewide dataset, the Queensland Hospital Admitted Patient Data Collection (QHAPDC). Data were analysed for all patients admitted to a Queensland hospital for a period of 24 hours or greater during the period 1 July 2001 to 31 December 2004 for the acute care phase of injury admission (ICD Diagnosis code range S00–T75 or T79).

The study was carried out at the National Centre for Health Information Research and Training (NCHIRT) (formerly known as the National Classification in Health (NCCH)), a Queensland University of Technology (QUT) research centre.

5.4.3 Data Source

The data used in this study were hospital separations unit records sourced from the Queensland Hospital Admitted Patients Data Collection (QHAPDC), as provided by the Australian Institute of Health and Welfare (AIHW). QHAPDC is the hospital morbidity dataset collected and maintained by the Queensland Health Department in accordance with national data dictionary standards. "QHAPDC contains data on all patients separated (an inclusive term meaning discharged, died, transferred or statistically separated) from any hospital permitted to admit patients, including public psychiatric hospitals." (Queensland Health, 2005) Data during this period were coded using the fourth edition of the Australian Modification of the International Classification of Diseases (ICD-10-AM).

The *QHAPDC Manual of instructions and procedures for the completion of patient identification and diagnosis data* (2006) provides the following guidance with regards to the structure and format of this data collection:

This collection contains information on all patients to Queensland hospitals. Included are all admitted patient separations from recognised public hospitals, licensed private hospitals and day surgery units. A separation can be a formal separation (including discharge, transfer or death) or a statistical separation (episode type changes). Departing the hospital on "leave" is only a separation when the duration of the "leave" is greater than seven days. Licensed private hospitals and day surgery units are also required to submit information for admitted patients. Specialist public psychiatric hospitals have been required to submit data to QHAPDC since 1 July 1996.

The external cause describes the precipitating event or accident leading to an injury or poisoning. External causes are coded using the current edition of the ICD10--AM. The external cause codes are listed in the range U50-Y98. Coding guidelines from 1 July 2000 require external cause code(s) to be linked to the diagnosis. An external cause code may be used in conjunction with any code in ICD10--AM but must be used with codes from S00-T98 and Z041-Z045 and for complications and abnormal reactions, which are classified outside the injury chapter (S00-T98). For example, if the principal diagnosis requires an external cause code(s) the external cause code(s) should be sequenced directly after the principal diagnosis then followed by any other diagnosis code(s). An external cause code(s) that relates to other diagnosis codes should be reported following the last of the other diagnosis codes that it relates to even if that external cause code is the same as the one that relates to the principal diagnosis. All other diagnosis codes that do not require an external cause code(s) should be sequenced after all codes that do require an external cause code(s).

A place of occurrence must be specified for ALL external cause codes in the range V01 – Y89, to denote the place of injury or poisoning. To indicate the place of occurrence, use codes from range Y92.00 – Y92.9 listed in the ICD10--AM Tabular List of Diseases, Volume 1, Fourth Edition, 1 July 2004.

An activity code is a separate code from range U50 – U73 for use with external cause codes V01 - Y34. These characters should not be confused with, or be used instead of the recommended place of occurrence code classifiable to V01 – Y89.

5.4.4 Variables

The data file contained the following variables for analysis:

Variable name	Variable description	Variable type
Year	Year of admission	Numeric
Sex	Patient sex	Categorical
Age	Patient age (years)	Numeric
Date of Birth	Patient date of birth	Date
Date of Admission	Date of hospital admission	Date
Date of Separation	Date of hospital separation	Date
CareType	Nature of service (i.e.acute care, rehabilitation etc.)	Categorical
Length of Stay	Hospital length of stay (in days)	Numeric
Separation Mode	Hospital separation mode (e.g. discharged alive, death etc.)	Categorical
RRMA	Rural, Remote and Metropolitan Areas	Categorical
Inj01_cat	ICD-10-AM Injury diagnosis code (first)	Categorical
D01	ICD-10-AM Principal diagnosis	Categorical
E01	ICD-10-AM First external cause of injury code (1st)	Categorical
E02	ICD-10-AM Second external cause of injury code (2nd)	Categorical
E03	ICD-10-AM Third external cause of injury code (3rd)	Categorical
PL01	ICD-10-AM Place of occurence code (1st)	Categorical
PL02	ICD-10-AM Place of occurence code (2nd)	Categorical
A01	ICD-10-AM Activity code (1st)	Categorical
A02	ICD-10-AM Activity code (2nd)	Categorical

5.4.5 Data Restrictions

The following restrictions were placed by AIHW on the provided records to ensure confidentiality of the data:

- Admitted patient records cannot be released in those cases where the patients LOS exceeded 21 days;

- Admitted patient records cannot be released in those cases where the patients age at admission exceeded 84 years;

- Admission weight, leave days and mental health legal status are not to be released.

The three date fields were confidentialised:

- Both date of admission and date of separation were back-shifted by an equivalent amount to preserve the length of stay of the original record;

- The date of birth field was confidentialised in a way that preserves the:

  a) age in years for patients aged 1 year or older;

  b) age in months for patients aged between 1 month and 12 months; and,

  c) age in days for patients aged less than 1 month.

5.4.6 Sample Selection

Data were extracted for all admitted cases with an ICD-10-AM injury code in the range of *S00-T75* or *T79* anywhere in the diagnosis string, and an ICD-10-AM external cause code (range *V00-Y98)* anywhere in the external cause code string. The definition of injury used for determination of the ICD code range for case selection was based upon the ‘community injury definition’ developed by Berry &

Harrison(Berry, 2007). This definition, developed and used by AIHW in reports on hospitalised injuries within Australia, identifies those injuries that have generally occurred in a community setting. Cases of injury as a consequence of adverse effects of medical care are a distinctly different causal subset that requires manifestly different countermeasures for prevention, and as such have been excluded from this study.

Only cases that were admitted to a ward for 24hrs or greater for the acute phase of treatment (i.e. not a readmission or rehabilitation episode) were included in the sample. As this study is focused on evaluating the extent and nature of external cause information documented within medical records, and subsequently coded in the hospital morbidity data collection, only cases of newly acquired injury are of interest. Unfortunately, Australian hospital morbidity data does not contain a unique patient identifier and hence, readmissions for treatment of the same injury are unable to be identified as a discrete group. To attempt to remove most cases where treatment is for a prior injury, cases involving non-acute care (e.g, multiple admissions for treatment or rehabilitation) were excluded from analysis as these cases would arguably have lower levels of information regarding the original injury event as this would have been documented at the time of the original presentation. In summary, the following injury group code ranges were excluded from the analyses:

- injuries as a consequence of complications of surgery and medical care (*T80-T88*);
- adverse effects not elsewhere classified (*T78*);
- other specified complications of trauma (*T89*);
- sequelae of injuries, of poisoning and of other consequences of external causes (*T90-T98*);
- cases coded with an 'Admission mode' of 'Non-acute care'.

QHAPDC has capacity to record an unlimited number of external cause codes. Coding guidelines dictate that if the principal diagnosis requires an external cause code, it be recorded immediately after the principal diagnosis. Any subsequent external cause code/s are to be reported after the last of the other diagnosis code/s to which it relates ((Queensland Health, 2005), p.901). This study examines the first assigned external cause code for each case, that is, the primary external cause code.

5.4.7 Data preparation

The data were prepared for analysis using SPSS. To prepare the data for analysis, the procedure was as follows:

1. All cases were examined to verify that an injury code was present in the diagnosis string

2. The first external cause, activity and place code within each record was moved into the primary code position in the dataset (E01; A01; P01). All analyses reported in this paper were performed using the external cause, activity and place codes appearing in these primary code positions (i.e. the first occurring codes in the record);

3. Alphanumeric ICD codes were parsed, splitting them into two variables: a string variable for the alpha portion; and, a numeric variable for the numeric portion of the ICD codes, to enable case selection based on alpha and numeric code range restrictions;

4. A SPSS syntax file was written to match merge the Defined/Undefined and Haddon's (Host, Agent, Environment, Energy) variables generated in for Study 1 onto the assigned External Cause code for each patient record.

5.5 *Analysis Methods*

All analyses were conducted using SPSS. Analysis of national morbidity data for 2001-4 was performed to identify:

1. Prevalence of principal injury diagnoses and key patient demographics for hospitalised injury cases (age, sex, gender, injury type);

2. Distribution of ICD-10-AM external cause codes in the QHAPDC dataset (by injury intent & mechanism), to identify high frequency code blocks; and

3. 'Information quality' of the morbidity dataset for injury research.

Codes were analysed using the Haddon's Element Present/Absent categorisations developed for Study 1. The percentage of codes assigned with Haddon's elements 'Present'/'Absent' were analysed for each Haddon's element to evaluate the match between the ICD-10-AM code system and the cases within the hospital morbidity dataset (i.e. the fit-for-purpose of the codes in application to a clinical dataset).

For distributional analyses only raw percentages are reported, as the entire population for the time period of interest are included in the analysis, thereby precluding the need for confidence intervals. Results of the analyses were formatted for presentation within the ICD-10 External Cause of Injury matrix format in use internationally. The results matrices are displayed for each Haddon's element separately (Host; Agent [Energy, Vector/Object, Vehicle/Perpetrator]; Environment).

Proportional utilisation rates of Haddon's Present/Absent codes were calculated to identify any blocks where codes with 'Absent' Haddon's element are overutilised. Rate ratio calculations were conducted to measure the proportional utilisation of Haddon's 'Absent' codes (i.e. poor information quality codes) in the QHAPDC dataset compared to the distribution of 'Absent' codes in the base code system.

Rate ratios were generated in the following manner:

- calculations were utilised from Study 1 (Refer to **Tables, 7, 9, 10, 11** & **13**) of the proportion of codes within ICD-10-AM with 'Absent' Haddon's elements. These tables, presented for each Haddon's element separately (Host, Energy, Vehicle/Object, Vector/Perpetrator & Environment), contain breakdowns by injury mechanism and intent code block of the number of codes with relevant Haddon's element information either 'Present' or 'Absent' in the code descriptor. These Tables were imported into Microsoft Excel for manipulation and analysis. For each mechanism code block, the rate of 'poor information quality' codes was calculated by dividing the number of codes 'Absent' of injury information relevant to Haddon's matrix by the total number of codes in the block. These rates form the denominators for the rate ratio calculations.
- identical Tables were generated from the Queensland hospital morbidity data (QHAPDC) used in this study. The rate of 'poor information quality' code usage in QHAPDC forms the numerator of the rate ratio. Formulae with 3-D cell references were written within Microsoft Excel to calculate rate ratios: ((*n[Haddon's Absent QHAPDC] / n[Total codes QHAPDC]) / (n[Haddon's Absent ICD-10-AM] / n[Total codes ICD-10-AM]*))

The rate ratios compare the utilisation of poor quality codes in the hospital morbidity dataset with the distribution of poor quality codes in the base code system. It is expected that in a high quality data system poor quality code usage should be proportional, or preferably underutilised, compared to the distribution of these codes in the underlying code system. A higher rate of poor quality codes in the coded dataset (i.e. a rate ratio >1) indicates overutilisation of poor quality codes, and identifies high priority areas for data improvement activities.

5.6 *Results*

5.6.1 Demographics

The mean age of patients admitted to a Qld hospital between Jan 2001 to 31st Dec 2004 for treatment of an injury was 38.2years (95% CI 38.1, 38.3). The majority of patients were male (61%; n=135,547), with a mean of 1.6 coded injuries per patient (95% CI: 1.6, 1.6). The average length of hospital stay for patients was 3.1 days (95% CI: 3.0, 3.1), and the majority of patients were discharged to home (85%, n = 187742). One percent (1%) of patients died in hospital (n = 1892), and the remainder were transferred to other hospital or facilities (14%, n = 32108). All injury patients had at least one external cause code within their record.

According to RRMA (Rural, Remote and Metropolitan Areas Classification) codes, almost half of all patients (48%, n = 105250) attended a Metropolitan hospital, 42% (n= 91374) were treated at a Regional hospital, and 10% of patients were admitted to Remote hospital facilities (data of hospital location was missing for 1.3% of cases).

Table 23 displays the frequency by primary injury site for patients admitted to hospital. The most prevalent injuries were those to the upper extremities (29.4%), lower extremities (23.9%), and head (19.5%).

Table 23 QHAPDC Frequency by Primary Injury Site

Injury type	N	%
Upper extremity	64712	29.2
Lower extremity	53030	23.9
Head	43234	19.5
Poisoning	22711	10.2
Abdomen, lower back, spine	12076	5.4
Thorax	7986	3.6
Foreign body	5783	2.6
Burns	4816	2.2
Neck	3705	1.7
Other effects of external causes	1941	0.9
Unspecified site	542	0.2
Other spine and trunk	397	0.2
Drowning	336	0.2
Asphyxiation	290	0.1
Multiple sites	183	0.1
Total	221742	100.0

Table 24 presents the frequencies of the major injury mechanism groups. Falls were the most prevalent injury mechanism, accounting for approximately one-third of all injuries. Roughly half as many cases (15%) were transport-related injuries, and the remaining injury mechanisms each accounted for between 9% and <1% of the injury caseload.

Table 24 QHAPDC Frequency by Injury Mechanism

Mechanism	N	%
Fall	71826	32%
All Transport	33636	15%
Struck by or against	22136	10%
Poisoning	20002	9%
Unspecified	19760	9%
Cut/Pierce	18117	8%
Other Specified, Classifiable	11925	5%
Natural/Environmental	9726	4%
Overexertion	4350	2%
Fire/hot object or substance	4171	2%
Machinery	3241	2%
Other Specified, nec	1184	1%
Suffocation	916	0%
Drowning	484	0%
Firearm	268	0%
Total	0	100%

5.6.2 Percentages of High 'Information Quality' Code Assignment

5.6.2.1 **Host Information**

The distribution of code assignments for Haddon's element of Host is displayed in **Table 25**. Across all injury code groups, the proportion of utilised codes that contained Host information was 31%, and 22% amongst unintentional injuries. There was marked variability by injury Mechanism Block in terms of the information quality of assigned codes for Host-related details. Codes assigned to 'All transport'-related codes contained host information in 95% of cases. Comparatively, codes used for Falls, the largest injury mechanism group, and Machinery, Overexertion, and Natural/Environmental injuries contained Host information in <1% of examined cases.

5.6.2.2 Energy Information

Approximately three-quarters (77%) of all injury codes assigned within the hospital morbidity dataset contained information relating to the Energy form of the injury. (**Table 26**) The Assault Intent block demonstrated a low percentage of codes containing Energy information (6%), and this was largely attributable to several mechanism blocks within this intent (i.e. Assault_Struck by or against; Assualt_Unspecified) which contain the preponderance of the Assault codes having no Energy information included.

There was variability in the percentage of ‘Present’ code usage across the mechanism blocks, with Unspecified (<1%), Other Specified (<1%), All Transport (44 %), and Struck by or against (58%) being the poorest blocks for Energy information. Comparatively, Drowning, Falls, Fire/hot object or substance, Firearm, Machinery Overextertion, Poisoning, Suffocation, and notably, Other Specified Classifiable mechanism blocks each contained energy information within all utilised codes (100%).

Table 25 QHAPDC Presence of Host Information

HOST	Haddon's Element	All Intents		Unintentional		Self Harm		Assault		Undetermined	
		n	%	n	%	n	%	n	%	n	%
All Injury	Present	68475	31	41466	22	13885	100	13124	96	0	0
	Absent	153267	69	151719	79	0	0	532	4	1016	100
	Total	**221742**	**100**	**193185**	**100**	**13885**	**100**	**13656**	**100**	**1016**	**100**
Cut/Pierce	Present	6929	38	4073	27	1586	100	1270	100	0	0
	Absent	11188	62	11085	73	0	0	0	0	103	100
	Total	**18117**	**100**	**15158**	**100**	**1586**	**100**	**1270**	**100**	**103**	**100**
Drowning	Present	5	1	0	0	3	100	2	100	0	0
	Absent	479	99	475	100	0	0	0	0	4	100
	Total	**484**	**100**	**475**	**100**	**3**	**100**	**2**	**100**	**4**	**100**
Fall	Present	94	0	0	0	63	100	31	100	0	0
	Absent	71732	100	71701	100	0	0	0	0	31	100
	Total	**71826**	**100**	**71701**	**100**	**63**	**100**	**31**	**100**	**31**	**100**
Fire/hot object or substance	Present	108	3	0	0	66	100	42	100	0	0
	Absent	4063	97	4051	100	0	0	0	0	12	100
	Total	**4171**	**100**	**4051**	**100**	**66**	**100**	**42**	**100**	**12**	**100**
Firearm	Present	105	39	0	0	45	100	60	100	0	0
	Absent	163	61	146	100	0	0	0	0	17	100
	Total	**268**	**100**	**146**	**100**	**45**	**100**	**60**	**100**	**17**	**100**
Machinery	Present	0	0	0	0						
	Absent	3241	100	3241	100						
	Total	**3241**	**100**	**3241**	**100**						
All Transport	Present	32067	95	32009	95	45	100	13	100		
	Absent	1569	5	1569	5	0	0	0	0		
	Total	**33636**	**100**	**33578**	**100**	**45**	**100**	**13**	**100**		
Natural/Environmental	Present	0	0	0	0						
	Absent	9726	100	9726	100						
	Total	**9726**	**100**	**9726**	**100**						
Overexertion	Present	0	0	0	0						
	Absent	4350	100	4350	100						
	Total	**4350**	**100**	**4350**	**100**						
Poisoning	Present	11596	58	0	0	11545	100	51	100	0	0
	Absent	8406	42	7691	100	0	0	0	0	715	100
	Total	**20002**	**100**	**7691**	**100**	**11545**	**100**	**51**	**100**	**715**	**100**
Struck by or against	Present	9361	42	0	0	16	100	9345	100	0	0
	Absent	12775	58	12760	100	0	0	0	0	15	100
	Total	**22136**	**100**	**12760**	**100**	**16**	**100**	**9345**	**100**	**15**	**100**
Suffocation	Present	372	41	0	0	348	100	24	100	0	0
	Absent	544	59	505	100	0	0	0	0	39	100
	Total	**916**	**100**	**505**	**100**	**348**	**100**	**24**	**100**	**39**	**100**
Other Specified, Classifiable	Present	5526	46	5384	48	26	100	116	18	0	0
	Absent	6399	54	5860	52	0	0	532	82	7	100
	Total	**11925**	**100**	**11244**	**100**	**26**	**100**	**648**	**100**	**7**	**100**
Other Specified, nec	Present	277	23	0	0	93	100	184	100	0	0
	Absent	907	77	896	100	0	0	0	0	11	100
	Total	**1184**	**100**	**896**	**100**	**93**	**100**	**184**	**100**	**11**	**100**
Unspecified	Present	2035	10	0	0	49	100	1986	100	0	0
	Absent	17725	90	17663	100	0	0	0	0	62	100
	Total	**19760**	**100**	**17663**	**100**	**49**	**100**	**1986**	**100**	**62**	**100**

Table 26 QHAPDC Presence of Energy Information

ENERGY	Haddon's Element	All Intents n	All Intents %	Unintentional n	Unintentional %	Self Harm n	Self Harm %	Assault n	Assault %	Undetermined n	Undetermined 4875
All Injury	Present	169773	77	155816	81	12141	87	873	6	943	93
	Absent	51969	23	37369	19	1744	13	12783	94	73	7
	Total	**221742**	**100**	**193185**	**100**	**13885**	**100**	**13656**	**100**	**1016**	**100**
Cut/Pierce	Present	15261	84	15158	100	0	0	0	0	103	100
	Absent	2856	16	0	0	1586	100	1270	100	0	0
	Total	**18117**	**100**	**15158**	**100**	**1586**	**100**	**1270**	**100**	**103**	**100**
Drowning	Present	484	100	475	100	3	100	2	100	4	100
	Absent	0	0	0	0	0	0	0	0	0	0
	Total	**484**	**100**	**475**	**100**	**3**	**100**	**2**	**100**	**4**	**100**
Fall	Present	71826	100	71701	100	63	100	31	100	31	100
	Absent	0	0	0	0	0	0	0	0	0	0
	Total	**71826**	**100**	**71701**	**100**	**63**	**100**	**31**	**100**	**31**	**100**
Fire/hot object or substance	Present	4171	100	4051	100	66	100	42	100	12	100
	Absent	0	0	0	0	0	0	0	0	0	0
	Total	**4171**	**100**	**4051**	**100**	**66**	**100**	**42**	**100**	**12**	**100**
Firearm	Present	268	100	146	100	45	100	60	100	17	100
	Absent	0	0	0	0	0	0	0	0	0	0
	Total	**268**	**100**	**146**	**100**	**45**	**100**	**60**	**100**	**17**	**100**
Machinery	Present	3241	100	3241	100						
	Absent	0	0	0	0						
	Total	**3241**	**100**	**3241**	**100**						
All Transport	Present	14878	44	14820	44	45	100	13	100		
	Absent	18758	56	18758	56	0	0	0	0		
	Total	**33636**	**100**	**33578**	**100**	**45**	**100**	**13**	**100**		
Natural/Environ mental	Present	9674	100	9674	100						
	Absent	52	1	52	1						
	Total	**9726**	**100**	**9726**	**100**						
Overexertion	Present	4350	100	4350	100						
	Absent	0	0	0	0						
	Total	**4350**	**100**	**4350**	**100**						
Poisoning	Present	20002	100	7691	100	11545	100	51	100	715	100
	Absent	0	0	0	0	0	0	0	0	0	0
	Total	**20002**	**100**	**7691**	**100**	**11545**	**100**	**51**	**100**	**715**	**100**
Struck by or against	Present	12775	58	12760	100	0	0	0	0	15	100
	Absent	9361	42	0	0	16	100	9345	100	0	0
	Total	**22136**	**100**	**12760**	**100**	**16**	**100**	**9345**	**100**	**15**	**100**
Suffocation	Present	916	100	505	100	348	100	24	100	39	100
	Absent	0	0	0	0	0	0	0	0	0	0
	Total	**916**	**100**	**505**	**100**	**348**	**100**	**24**	**100**	**39**	**100**
Other Specified, Classifiable	Present	11925	100	11244	100	26	100	648	100	7	100
	Absent	0	0	0	0	0	0	0	0	0	0
	Total	**11925**	**100**	**11244**	**100**	**26**	**100**	**648**	**100**	**7**	**100**
Other Specified, nec	Present	2	0	0	0	0	0	2	1	0	0
	Absent	1182	100	896	100	93	100	182	99	11	100
	Total	**1184**	**100**	**896**	**100**	**93**	**100**	**184**	**100**	**11**	**100**
Unspecified	Present	0	0	0	0	0	0	0	0	0	0
	Absent	19760	100	17663	100	49	100	1986	100	62	100
	Total	**19760**	**100**	**17663**	**100**	**49**	**100**	**1986**	**100**	**62**	**100**

5.6.2.3 Vehicle/Object Information

Vehicle/Object information was applicable to 94% of QHAPDC cases (n=207,666; excluding Natural/Environmental & Overexertion mechanisms), and was present in 64% of all assigned codes. (**Table 27**) Unintentional injuries, the largest intent block, was lowest with only 60% of utilised codes being 'Present' for Vehicle/Object information.

Amongst the Mechanism blocks, assigned Fall codes contained Object information in only 35% of cases, and in 32% of cases for Suffocation injuries. Drowning, Other Specified nec and Unspecified codes contained no Vehicle or Object information. The majority of remaining mechanism code blocks, including All Transport and Other Specified Classifiable, contained Vehicle/Object information in greater than 80% of cases, with variability across Intent blocks.

5.6.2.4 Vector/Perpetrator Information

Vector/Perpetrator information was applicable to 21% of coded cases (n=46543), primarily relating to Transport and Assault code blocks. Overall, approximately two-thirds (69%) of assigned codes contained Vector or Perpetrator information (where applicable. (Table 26) Vector information was only available for 56% of Transport cases, and 57% of all Assault codes. Unspecified Assaults and Assault_Fall contained the lowest proportion of Perpetrator information out of all of the Assault code blocks (41% & 48%, respectively).

Table 27 QHAPDC Prevalence of Vehicle/Object Information

VEHICLE / OBJECT	Haddon's Element	All Intents		Unintentional		Self Harm		Assault		Undetermined	
		n	%	n	%	n	%	n	%	n	%
All Injury	Present	132567	64	108072	60	13020	94	10623	78	852	84
	Absent	75099	36	71037	40	865	6	3033	22	164	16
	Total	**207666**	**100**	**179109**	**100**	**13885**	**100**	**13656**	**100**	**1016**	**100**
Cut/Pierce	Present	17609	97	15158	100	1277	81	1088	86	86	84
	Absent	508	3	0	0	309	20	182	14	17	17
	Total	**18117**	**100**	**15158**	**100**	**1586**	**100**	**1270**	**100**	**103**	**100**
Drowning	Present	0	0	0	0	0	0	0	0	0	0
	Absent	484	100	475	100	3	100	2	100	4	100
	Total	**484**	**100**	**475**	**100**	**3**	**100**	**2**	**100**	**4**	**100**
Fall	Present	24906	35	24906	35	0	0	0	0	0	0
	Absent	46920	65	46795	65	63	100	31	100	31	100
	Total	**71826**	**100**	**71701**	**100**	**63**	**100**	**31**	**100**	**31**	**100**
Fire/hot object or substance	Present	3412	82	3292	81	66	100	42	100	12	100
	Absent	759	18	759	19	0	0	0	0	0	0
	Total	**4171**	**100**	**4051**	**100**	**66**	**100**	**42**	**100**	**12**	**100**
Firearm	Present	268	100	146	100	45	100	60	100	17	100
	Absent	0	0	0	0	0	0	0	0	0	0
	Total	**268**	**100**	**146**	**100**	**45**	**100**	**60**	**100**	**17**	**100**
Machinery	Present	3241	100	3241	100						
	Absent	0	0	0	0						
	Total	**3241**	**100**	**3241**	**100**						
All Transport	Present	33001	98	32943	98	45	100	13	100		
	Absent	635	2	635	2	0	0	0	0		
	Total	**33636**	**100**	**33578**	**100**	**45**	**100**	**13**	**100**		
Natural/Environmental	Present										
	Absent										
	Total										
Overexertion	Present										
	Absent										
	Total										
Poisoning	Present	20002	100	7691	100	11545	100	51	100	715	100
	Absent	0	0	0	0	0	0	0	0	0	0
	Total	**20002**	**100**	**7691**	**100**	**11545**	**100**	**51**	**100**	**715**	**100**
Struck by or against	Present	18855	85	9479	74	16	100	9345	100	15	100
	Absent	3281	15	3281	26	0	0	0	0	0	0
	Total	**22136**	**100**	**12760**	**100**	**16**	**100**	**9345**	**100**	**15**	**100**
Suffocation	Present	291	32	291	58	0	0	0	0	0	0
	Absent	625	68	214	42	348	100	24	100	39	100
	Total	**916**	**100**	**505**	**100**	**348**	**100**	**24**	**100**	**39**	**100**
Other Specified, Classifiable	Present	10980	92	10925	97	26	100	22	3	7	100
	Absent	945	8	319	3	0	0	626	97	0	0
	Total	**11925**	**100**	**11244**	**100**	**26**	**100**	**648**	**100**	**7**	**100**
Other Specified, nec	Present	2	0	0	0	0	0	2	1	0	0
	Absent	1182	100	896	100	93	100	182	99	11	100
	Total	**1184**	**100**	**896**	**100**	**93**	**100**	**184**	**100**	**11**	**100**
Unspecified	Present	0	0	0	0	0	0	0	0	0	0
	Absent	19760	100	17663	100	49	100	1986	100	62	100
	Total	**19760**	**100**	**17663**	**100**	**49**	**100**	**1986**	**100**	**62**	**100**

Table 28 QHAPDC Presence of Vector/Perpetrator Information

VECTOR / PERPETRATOR	Haddon's Element	All Intents n	All Intents %	Unintentional n	Unintentional %	Self Harm n	Self Harm %	Assault n	Assault %	Undetermined n	Undetermined %
All Injury	Present	32167	69	24353	74	45	100	7769	57		
	Not Present	14376	31	8489	26	0	0	5887	43		
	Total	**46543**	**100**	**32842**	**100**	**45**	**100**	**13656**	**100**		
Cut/Pierce	Present	821	65					821	65		
	Not Present	449	35					449	35		
	Total	**1270**	**100**					**1270**	**100**		
Drowning	Present	2	100					2	100		
	Not Present	0	0					0	0		
	Total	**2**	**100**					**2**	**100**		
Fall	Present	15	48					15	48		
	Not Present	16	52					16	52		
	Total	**31**	**100**					**31**	**100**		
Fire/hot object or substance	Present	34	81					34	81		
	Not Present	8	19					8	19		
	Total	**42**	**100**					**42**	**100**		
Firearm	Present	43	72					43	72		
	Not Present	17	28					17	28		
	Total	**60**	**100**					**60**	**100**		
Machinery	Present										
	Not Present										
	Total										
All Transport	Present	10508	56	10450	56	45	100	13	100		
	Not Present	8302	44	8302	44	0	0	0	0		
	Total	**18810**	**100**	**18752**	**100**	**45**	**100**	**13**	**100**		
Natural/Environmental	Present	9553	98	9553	98						
	Not Present	173	2	173	2						
	Total	**9726**	**100**	**9726**	**100**						
Overexertion	Present	4350	100	4350	100						
	Not Present	0	0	0	0						
	Total	**4350**	**100**	**4350**	**100**						
Poisoning	Present	41	80					41	80		
	Not Present	10	20					10	20		
	Total	**51**	**100**					**51**	**100**		
Struck by or against	Present	5354	57					5354	57		
	Not Present	3991	43					3991	43		
	Total	**9345**	**100**					**9345**	**100**		
Suffocation	Present	20	53	0	0			20	83		
	Not Present	18	47	14	100			4	17		
	Total	**38**	**100**	**14**	**100**			**24**	**100**		
Other Specified, Classifiable	Present	485	75					485	75		
	Not Present	163	25					163	25		
	Total	**648**	**100**					**648**	**100**		
Other Specified, nec	Present	120	65					120	65		
	Not Present	64	35					64	35		
	Total	**184**	**100**					**184**	**100**		
Unspecified	Present	821	41					821	41		
	Not Present	1165	59					1165	59		
	Total	**1986**	**100**					**1986**	**100**		

5.6.2.5 Environment Information

Across all assigned codes within the QHAPDC dataset, 30% of codes contained Environment information. (**Table 29**) This highest percentage of codes with Environment information was amongst the Unintentional injury code block (34% Present). On average, <3% of Self Harm, Assault and Undetermined Intent codes contained any Environment information.

Across injury mechanisms, a large number of blocks contain no Environment information at all (Cut/Pierce, Firearm, Machinery, Natural/Environmental, Overexertion, Poisoning, Struck by or against, Other Specified Classifiable, Other Specified nec, Unspecified). The mechanism blocks with the highest levels of Present Environment information were Transport (84%), Drowning (82%), and Falls (52%).

Table 29 QHAPDC Presence of Environment Information

ENVIRONMENT	Haddon's Element	All Intents n	All Intents %	Unintentional n	Unintentional %	Self Harm n	Self Harm %	Assault n	Assault %	Undetermined n	Undetermined %
All Injury	Present	66416	30	66291	34	46	0	46	0	33	3
	Not Present	155326	70	126894	66	13839	100	13610	100	983	97
	Total	**221742**	**100**	**193185**	**100**	**13885**	**100**	**13656**	**100**	**1016**	**100**
Cut/Pierce	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	18117	100	15158	100	1586	100	1270	100	103	100
	Total	**18117**	**100**	**15158**	**100**	**1586**	**100**	**1270**	**100**	**103**	**100**
Drowning	Present	397	82	392	83	1	33	2	100	2	50
	Not Present	87	18	83	18	2	67	0	0	2	50
	Total	**484**	**100**	**475**	**100**	**3**	**100**	**2**	**100**	**4**	**100**
Fall	Present	37411	52	37349	52	0	0	31	100	31	100
	Not Present	34415	48	34352	48	63	100	0	0	0	0
	Total	**71826**	**100**	**71701**	**100**	**63**	**100**	**31**	**100**	**31**	**100**
Fire/hot object or substance	Present	323	8	323	8	0	0	0	0	0	0
	Not Present	3848	92	3728	92	66	100	42	100	12	100
	Total	**4171**	**100**	**4051**	**100**	**66**	**100**	**42**	**100**	**12**	**100**
Firearm	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	268	100	146	100	45	100	60	100	17	100
	Total	**268**	**100**	**146**	**100**	**45**	**100**	**60**	**100**	**17**	**100**
Machinery	Present	0	0	0	0						
	Not Present	3241	100	3241	100						
	Total	**3241**	**100**	**3241**	**100**						
All Transport	Present	28279	84	28221	84	45	100	13	100		
	Not Present	5357	16	5357	16	0	0	0	0		
	Total	**33636**	**100**	**33578**	**100**	**45**	**100**	**13**	**100**		
Natural/Environ mental	Present	0	0	0	0						
	Not Present	9726	100	9726	100						
	Total	**9726**	**100**	**9726**	**100**						
Overexertion	Present	0	0	0	0						
	Not Present	4350	100	4350	100						
	Total	**4350**	**100**	**4350**	**100**						
Poisoning	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	20002	100	7691	100	11545	100	51	100	715	100
	Total	**20002**	**100**	**7691**	**100**	**11545**	**100**	**51**	**100**	**715**	**100**
Struck by or against	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	22136	100	12760	100	16	100	9345	100	15	100
	Total	**22136**	**100**	**12760**	**100**	**16**	**100**	**9345**	**100**	**15**	**100**
Suffocation	Present	6	1	6	1	0	0	0	0	0	0
	Not Present	910	99	499	99	348	100	24	100	39	100
	Total	**916**	**100**	**505**	**100**	**348**	**100**	**24**	**100**	**39**	**100**
Other Specified, Classifiable	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	11925	100	11244	100	26	100	648	100	7	100
	Total	**11925**	**100**	**11244**	**100**	**26**	**100**	**648**	**100**	**7**	**100**
Other Specified, nec	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	1184	100	896	100	93	100	184	100	11	100
	Total	**1184**	**100**	**896**	**100**	**93**	**100**	**184**	**100**	**11**	**100**
Unspecified	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	19760	100	17663	100	49	100	1986	100	62	100
	Total	**19760**	**100**	**17663**	**100**	**49**	**100**	**1986**	**100**	**62**	**100**

5.6.2.6 Place of Occurrence

Cases within the QHAPDC data were examined for the presence of a Place of Occurrence code, which conveys information regarding the geographical location of the injury event (refer **Table 30**). Across all cases, 57% had a Place of Occurrence code assigned. Place of Occurrence code presence was examined by injury mechanism block, with some variation evidenced between code blocks. The lowest quality block for Place of Occurrence information was Unspecified injuries (17% Present), and the highest quality mechanism blocks were Drowning, Falls, Fire/Hot object or substance, All transport, Poisoning, and Suffocation (67-70% Present). The remaining mechanism code blocks, including Other Specified nec and Other Specified Classifiable injuries, ranged between 44 and 57% for the presence of a Place of Occurrence code.

Table 30 Place of Occurrence Code by Mechanism of Injury

Place of Occurrence		n	%
All Injury	Present	126072	57
	Absent	95670	43
Cut/Pierce	Present	8245	46
	Absent	9872	54
Drowning	Present	338	70
	Absent	146	30
Fall	Present	48597	68
	Absent	23229	32
Fire/hot object or substance	Present	2785	67
	Absent	1386	33
Firearm	Present	128	48
	Absent	140	52
Machinery	Present	1835	57
	Absent	1406	43
All Transport	Present	23058	69
	Absent	10578	31
Natural/Environmental	Present	4371	45
	Absent	5355	55
Overexertion	Present	2496	57
	Absent	1854	43
Poisoning	Present	13764	69
	Absent	6238	31
Struck by or against	Present	10617	48
	Absent	11519	52
Suffocation	Present	613	67
	Absent	303	33
Other Specified, Classifiable	Present	5292	44
	Absent	6633	56
Other Specified, nec	Present	634	54
	Absent	550	46
Unspecified	Present	3299	17
	Absent	16461	83

5.6.2.7 Activity at Time of Injury

The presence of an Activity code, describing what the injured person was doing at the time of their injury event, was analysed (refer **Table 31**). Across all cases, 47% had an Activity code assigned that conveyed an aspect of the injury event. Activity code presence was examined by injury mechanism block, the lowest quality blocks for Activity information being Overexertion (28% Present), Drowning (31% Present), and Other Specified nec injuries (35% Present). The mechanism group associated with the highest rate of Activity codes was Poisoning mechanism (62% Present).

Table 31 Activity at Time of Injury by Mechanism

Activity at Time of Injury		n	%
All Injury	Present	104866	47
	Absent	116876	53
Cut/Pierce	Present	8183	45
	Absent	9934	55
Drowning	Present	152	31
	Absent	332	69
Fall	Present	32808	46
	Absent	39018	54
Fire/hot object or substance	Present	1849	44
	Absent	2322	56
Firearm	Present	142	53
	Absent	126	47
Machinery	Present	680	21
	Absent	2561	79
All Transport	Present	16504	49
	Absent	17132	51
Natural/Environmental	Present	4372	45
	Absent	5354	55
Overexertion	Present	1235	28
	Absent	3115	72
Poisoning	Present	12345	62
	Absent	7657	38
Struck by or against	Present	9899	45
	Absent	12237	55
Suffocation	Present	422	46
	Absent	494	54
Other Specified, Classifiable	Present	4800	40
	Absent	7125	60
Other Specified, nec	Present	418	35
	Absent	766	65
Unspecified	Present	11057	56
	Absent	8703	44

5.6.3 ICD in Application: Proportional Utilisation of Code Quality

The proportional utilisation of Haddon's element 'absent' codes (i.e. poor information quality codes) was examined in QHAPDC to identify high priority code blocks for data improvement activities. Baseline distributions of these codes in the ICD-10-AM code structure were used as a reference to identify code blocks where poor quality codes are overrepresented in the coded dataset. Rate ratios are presented comparing the rate of Absent Haddon's elements in the ICD-10-AM code system to the rate of Haddon's Absent elements in the coded morbidity dataset. The results of these analyses are presented as tables of rates and rate ratios. As estimates are provided on the basis of a sample of hospital morbidity records, confidence intervals are provided as a measure of reliability of these estimates.

Two tables of rate ratios are presented following to identify low information quality code blocks as priorities for development. The first, **Table 32**, identifies those code blocks where poor quality codes (i.e. Haddon's element absent)z are overrepresented in the coded morbidity dataset (QHAPDC) by comparison to their rate of occurrence in the base ICD code system. A Rate Ratio >1.0 was defined as the researcher as representing overutilisation of poor quality codes. A minimum threshold for inclusion as a priority area for development was set at a rate of .10 (i.e. 10%) or greater 'Absent' Haddon's elements, for either the ICD code system or QHAPDC. Absent information at a level of 10% or greater was considered to be unacceptably high in terms of resulting compromise to data quality. **Table 33** displays code blocks with a very high base rate of poor quality codes (>.50) within the ICD-10-AM classification system, and where the usage of these codes in the morbidity dataset is proportionately high. Rate ratios for the remainder of the ICD code set (i.e. low priority code blocks) are available in **Appendix 5**.

Table 32 Overutilised Haddon's Element 'Absent' Codes

		QHAPDC Rate	ICD Rate	Rate Ratio	Confidence Interval (Lower)	Confidence Interval (Upper)
ALL						
Host	All Injury	0.69	0.18	3.92	3.55	4.33
	Cut/Pierce	0.62	0.14	4.38	2.42	7.91
	Drowning	0.99	0.24	4.19	2.58	6.80
	Fire/hot object or substance	0.97	0.57	1.71	1.19	2.47
	Firearm	0.61	0.16	3.70	2.10	6.50
	Poisoning	0.42	0.27	1.53	1.06	2.22
	Other Specified, nec	0.77	0.14	5.36	1.34	21.47
	Unspecified	0.90	0.15	5.83	1.46	23.32
Agent	All Injury	0.10	0.01	9.25	6.15	13.93
	Other Specified, nec	0.90	0.36	2.52	1.05	6.06
	Unspecified	0.96	0.38	2.49	1.04	5.99
Environment	All Injury	0.70	0.32	2.17	2.02	2.33
	All Transport	0.16	0.07	2.16	1.79	2.60
Energy	All Injury	0.23	0.18	1.29	1.17	1.43
	All Transport	0.56	0.18	3.04	2.70	3.42
Vector/Object	All Injury	0.34	0.07	4.77	4.08	5.57
	Drowning	1.00	0.36	2.77	1.87	4.11
Vehicle/Perp	All Transport	0.25	0.04	6.63	5.12	8.59
UNINTENTIONAL						
Host	All Injury	0.79	0.19	4.10	3.68	4.57
Agent	All Injury	0.10	0.01	18.80	9.78	36.14
Environment	All Injury	0.66	0.19	3.40	3.05	3.79
	All Transport	0.16	0.08	2.03	1.69	2.44
Energy	All Transport	0.56	0.20	2.86	2.54	3.21
Vector/Object	All Injury	0.40	0.02	19.49	13.86	27.42
	Drowning	1.00	0.17	6.00	1.50	24.06
	Fall	0.65	0.23	2.86	1.43	5.71
Vehicle/Perp	All Injury	0.26	0.04	6.90	5.18	9.19
	All Transport	0.44	0.04	12.35	9.12	16.73
ASSAULT						
Agent	All Injury	0.10	0.02	5.44	2.71	10.89
Environment	All Injury	1.00	0.73	1.37	1.23	1.53
Energy	All Injury	0.94	0.23	4.12	3.38	5.01
Vector/Object	Other Specified, nec	0.99	0.53	1.88	0.99	3.55
Vehicle/Perp	All Injury	0.43	0.20	2.16	1.75	2.66
	Cut/Pierce	0.35	0.20	1.77	1.00	3.14

Table 33 Proportional Utilisation High Prevalence 'Absent' Elements

		QHAPDC Rate	ICD Rate	**Rate Ratio**	Confidence Interval (Lower)	Confidence Interval (Upper)
ALL						
Host	Fall	1.00	0.77	**1.30**	0.94	1.81
Environment	Natural/Environmental	1.00	0.99	**1.01**	0.81	1.26
	Suffocation	0.99	0.90	**1.10**	0.70	1.73
UNINTENTIONAL						
Environment	Fire/hot object or substance	0.92	0.85	**1.08**	0.72	1.63
	Natural/Environmental	1.00	0.99	**1.01**	0.81	1.26
	Suffocation	0.99	0.78	**1.27**	0.60	2.68
Energy	Other Specified, nec	1.00	0.93	**1.08**	0.62	1.86
Vector/Object	Suffocation	0.42	0.67	**0.64**	0.28	1.43
SELF HARM						
Environment	All Injury	1.00	0.77	**1.29**	0.94	1.79
ASSAULT						
Energy	Other Specified, nec	0.99	0.91	**1.09**	0.58	2.06
UNDETERMINED						
Environment	All Injury	0.97	0.76	**1.28**	0.92	1.78

Analysing across all injury mechanisms and intents, poor quality ICD codes are overutilised for all Haddon's elements with exception of the Vehicle/Perpetrator category. In the example of Host information, in ICD 18% of codes are absent of relevant information, however when the codes have been applied to QHAPDC the rate increases to 69%. This equates to a 3.9 fold increase in the use of poor quality codes by comparison the rate of poor quality codes in the underlying ICD-10-AM code system. Use of poor quality codes is also disproportionately high across all injuries for the following Haddon's elements: Agent (10% of assigned codes of poor quality), Environment (70% of codes assigned of poor quality), Energy (23% of assigned codes of poor quality), Vector/Object (34% of assigned codes of poor quality).

Poor quality codes for Transport-related injuries were overutilised in a number of injury categories for Environment, Energy, and Vehicle/Perp information. Notably, the only category that Falls appear in is for Vector/Object information in the Unintentional injury group, (2.86 times overrepresented in QHAPDC).

Poor quality codes relating to Environment information, both overutilised and proportional high utilisation, were identified for a number of injury mechanism and intent groups.

5.6.4 Summary of Results

The proposed Haddon's framework for evaluation of data and information quality was applied to Queensland Hospital morbidity data to assess the 'fit-for-purpose' of the data collection for injury research. The information quality of QHAPDC data was evaluated by merging the Haddon's categorisations developed in Study 1 with the ICD-10-AM external cause of injury codes as applied in QHAPDC.

Frequency analyses displayed the incidence of poor information quality codes for specific injury groups within the QHAPDC data. A large amount of variation in the distribution of quality code usage was evidenced across injury mechanism and intent groups. To aid interpretation, a summary of the percentage of QHAPDC cases with 'Present' Haddon's elements is presented below in **Table 34** by key injury code groups. The groups have been selected on the following basis:

- All injuries to provide a summary description across the entire dataset;

- All Transport codes as transport codes represent 70% of the ICD-10-AM external cause of injury code set;
- Falls injuries as the highest incidence injury group;
- Unspecified, Other Specified nec, and Other Specified Classifiable residual mechanism categories

Further evaluation of ICD-10-AM external cause of injury codes in application was undertaken by comparing the proportional utilisation of high and low quality codes in the morbidity dataset by comparison to the underlying distribution with the ICD-10-AM code set. This was performed to identify priority areas for code system development. Code blocks with low rates of utilisation for codes with present Haddon's element information, or proportional high usage of poor quality codes, both present high priority areas for classification development. There was variation by Intent and Mechanism groups, with a large number of individual 'poor quality' code categories identified. A summary of key code blocks by percentage of present Haddon's elements within the ICD code system and QHAPDC data collection, with corresponding proportional utilisation rates is also presented in **Table 34**, below.

Table 34 Haddon's Elements by Key Code Blocks: ICD-10-AM & QHAPDC

All Intents		Host		Energy		Vehicle/Object		Vector/Perpetrator		Environment	
		ICD	QHAPDC	ICD	QHAPDC	ICD	QHAPDC	ICD	QHAPDC	ICD	QHAPDC
All Injuries	% Present	82	31	82	77	93	64	92	69	68	30
	Utilisation rate	**0.4**		**0.9**		**0.7**		**0.8**		**0.4**	
All Transport	% Present	94	95	82	44	99	98	78	56	93	84
	Utilisation rate	**1.0**		**0.5**		**1.0**		**0.7**		**0.9**	
Falls	% Present	23	0	100	100	57	35	80	48	43	52
	Utilisation rate	**0.0**		**1.0**		**0.6**		**0.6**		**1.2**	
Unspecified	% Present	85	10	0	n/a	0	n/a	80	41	0	n/a
	Utilisation rate	**0.1**		**n/a**		**n/a**		**0.5**		n/a	
Other Specified nec	% Present	86	23	7	0	7	0	82	65	0	n/a
	Utilisation rate	**0.3**		**0.0**		**0.0**		**0.8**		**n/a**	
Other Specified Classifiable	% Present	45	46	100	100	55	92	80	75	0	n/a
	Utilisation rate	**1.0**		**1.0**		**1.7**		**0.9**		**n/a**	

Host and Environment elements had the poorest coverage across all injury types (31% and 30%, respectively). Notably, despite the Unspecified, Other Specified nec, and Other Specified Classifiable residual mechanism categories being described by traditional data quality measures and being 'Undefined' codes, some code categories contained relatively high levels of pertinent injury information (e.g., 65% of Other Specified nec codes contained relevant Vector/Perpetrator information).

Across all injury mechanisms and Haddon's elements, codes with present Haddon's information were underrepresented in the coded QHAPDC dataset by comparison to the ICD code system. Further examination by key injury mechanisms shows greater variance across groups. There were only two code groups in which codes with Present Haddon's elements were used at a higher frequency in the coded data than in the underlying code system: Other Specified Classifiable codes for Vehicle/Object information (utilisation rate = 1.7); and notably, Falls codes for Environment information (utilisation rate = 1.2). Despite the higher utilisation rate of codes with present Environment information for Falls injuries, these codes still only represented 52% of assigned codes. Comparatively, whilst 23% of Falls codes in ICD contain Host information none of these codes were applied to the coded QHAPDC dataset, and codes with present Vehicle/Object and Vector/Perpetrator information were also underrepresented (utilisation rates = 0.6).

Other notable injury groups where high quality codes were underutilised were All injuries for both Host (utilisation rate = 0.4) and Environment (utilisation rate = 0.4), and Other Specified nec codes for Host information (utilisation rate = 0.3).

5.7 *Discussion*

The key objectives of this study were to evaluate the 'fit-for-purpose' information quality of ICD-10-AM codes in context; and identify priority areas for quality improvement, based upon high frequency code blocks with low information quality.

What is the 'information quality' of the Queensland hospital morbidity dataset for injury research? Does the information quality vary by injury mechanism and intent? What are the relative utilisation rates within the hospital morbidity dataset of 'high' and 'low' information quality codes, identified in Study 1?

Coverage of Haddon's elements within the coded dataset is inconsistent across injury groups. Across all injury code blocks the presence of Haddon's information elements ranged from 30% and 31% for Environment and Host information, respectively, to 77% for Energy information. There was large variation across injury mechanism blocks in terms of the percentage of codes used that contained specific injury details. Host information was mainly available for intentional causes and unintentional transport codes only, thus the percentage of present Host information largely reflected the prevalence of these causes. Presence of Host information was less than 50% for all other injury mechanism blocks.

Examination of the key injury mechanism code blocks of Falls and Transport-related injuries identified marked variation within each code block across the Haddon's elements. Within the coded QHAPDC dataset, there was a high presence of Host and Vehicle/Object information for Transport injuries, and Energy for Falls injuries. However, Falls lacked any codes with Host information, only third contained Vehicle/Object details, and approximately a half had information relating to the Environment. By comparison, Transport-related codes applied to the data contained Energy information in less than half of cases, and Vector/Perpetrator information in just over half. Despite the highly structured nature of transport-related codes, with explicit inclusion of Environment information for the majority codes (e.g. traffic/non-traffic area), Environment information was still absent in 16% of cases.

The consequence of a large degree of absent detail regarding injury causation factors amongst ICD external cause of injury codes is a reduction in information quality of the resulting coded datasets. For injury researchers this leads to a lessening in the ability to identify causes and risk factors for injuries, and therefore the capacity to develop specific and effect prevention strategies.

Notably, despite the Unspecified, Other Specified nec, and Other Specified Classifiable residual mechanism categories being described by traditional data quality measures and being 'Undefined' codes, some code categories contained relatively high levels of pertinent injury information (e.g., 65% of Other Specified nec codes contained relevant Vector/Perpetrator information). Thus, whilst a certain aspect/s of a code may be lacking detail, the code may still present information regarding other aspects of the injury causation which is of use to injury researchers. This demonstrates the utility, when examining injury data quality, of adopting a less rudimentary measure by dissecting the coded information into relevant information subcomponents aligned with injury prevention theory.

Can high priority code blocks for quality improvement be identified due to either a high prevalence or overutilisation of codes with 'Absent' Haddon's elements (Host, Agent, Environment information)?

Rates and rate ratios of Haddon's 'Absent' code usage were calculated to identify priority areas for quality improvement. Code blocks were considered to be of high priority for development if they contained either a high rate of Haddon's 'Absent' codes in the ICD-10-AM code system, or if poor quality codes were overutilised when applied to the coding of hospital morbidity data. Both scenarios present key opportunities for data improvement. A large number of poor quality (Haddon's 'Absent') codes, across Intent and Mechanism code groups, were overutilised in the coding of hospital morbidity data compared to their distribution throughout the ICD-10-AM code system. No consistent patterns of variation were identified as associated with any particular Intent and Mechanism code block combinations. This indicates that the current structure of the ICD code system provides inconsistent coverage of key injury causation elements across a wide array of injury groups. The detailed breakdown of injury intent and mechanism code blocks by presence/absence of each specific Haddon's element (Tables 26 to 29) provides a valuable evidence base that can be used in future classification system development activities to identify specific code blocks for focussed development activities.

Across intent groups, All Transport codes featured prominently in overutilised poor quality codes. This is despite the transport section of the ICD-10-AM code system being the most detailed of injury mechanism groups. The section of Transport-related external cause of injury codes contains a large number of pre-coordinated codes that contain various Host, Agent, Vehicle/Object, Vector/Perpetrator and Environment factors in numerous combinations. Transport-related codes account for 70% (n = 1559) of all ICD-10-AM external cause of injury codes, whilst Transport-related injuries comprise only account for 15.4% of all hospitalised injury cases. Despite the wide array of transport-related codes, poor quality codes were overrepresented in the QHAPDC coded dataset.

By comparison, overutilised poor quality Falls codes only featured in two code groups. Notably, there was an overuse of absent Object codes, which is a critical element to informing falls prevention activities to address the underlying objects causing fall injuries, and thereby requires addressing. But, to provide context in relation to the predominance of transport-related codes, Falls represent 32% of hospitalised injury cases, but Falls codes account for a mere 2% of codes within the ICD-10-AM code set. The disparity in code availability and code usage within the classification system highlights the need for classification development. In addition, the prevalence of poor quality code usage amongst Transport-related cases, compared to Falls related injuries, illustrates that a hefty code set with a large number of pre-coordinated combinations may not be the optimal strategy.

One injury factor that was identified as being consistently lacking was that of Environment, which was absent in ICD for a large number of mechanism blocks. Accordingly, poor quality codes for Environment information had high utilisation levels across numerous injury mechanism groups within the coded QHAPDC dataset. Environment is a pivotal information aspect regarding the causal circumstances of injury events, and thereby represents a key area for further development within the code system.

5.7.1 Limitations of Study

For this study only one external cause code per patient could be examined, however multiple codes can be assigned in the medical record. It is therefore possible that further codes, where present, may have contained additional injury information to that contained in the examined primary external cause of injury code. It should be noted though that examination of the data collection identified that approximately two-thirds of records (64.6%) contained only one external cause code entry, 32.6% contained two external cause codes, and only 2.8% contained 3 or more. Therefore, in the majority of cases only one external cause code was present; this minimises the potential impact of exclusion of additional external cause codes on the results of this study.

In a number of injury code groups, where a Haddon’s element has been coded as 100% Present within an entire code group, this tends to be as a result of the Haddon’s element being contained in either the Intent or Mechanism descriptor. This was particularly common for Host information (e.g. ‘self-harm’, ‘assault). This is relevant and valuable injury causation information, and for this reason it was included in the assessment of the presence/absence of each Haddon’s element. However, this is very broad information, and the sufficiency of this level of detail will be dependent upon the purpose of the end-user.

In the breakdowns of code information quality by injury Intent and Mechanism for each Haddon's element there was marked variability amongst individual cells, in some cases this was due to small cell numbers. As a result, no consistent pattern to the variation was evidenced by each Mechanism and Intent code block combination. Therefore, based upon the findings of Study 1 and 2, further analyses will not be broken down to Intent by Mechanism level, as resulting variation is too sporadic to be informative. For the purpose of measuring and describing the current code system and resulting dataset Mechanism blocks provide the best summary descriptive level.

For this study, Place of Occurrence & Activity codes were assessed on the basis of presence/absence of code only, with no assessment as to the information contribution of each code. Due to the structure of the ICD-10-AM code system, with separate discrete codes for Place of Occurrence and Activity, it is difficult for analysis purposes to match these codes to the corresponding external cause code within the hospital record. Additionally, it is not feasible to examine every combination of external cause of injury code and Place of Occurrence and Activity code. For this reason further analysis of these codes was not undertaken as it was deemed to be of little value, and Place of Occurrence and Activity codes have been excluded from any further analysis.

In classifying the presence/absence of each Haddon's element it was identified that there was overlap between several aspects of injury circumstances, in particular between Agent, Energy and Vehicle. For this reason for further analyses these aspects with be grouped into the element Mechanism, with the other elements being Host, Object/Perpetrator, and Environment.

5.7.2 For Further Investigation

There is a need to evaluate why coders are assigning poor information quality codes in preference to codes that specify more details regarding the injury circumstances.

This study has identified numerous priority areas that require addressing within the ICD-10-AM external cause of injury code system. However, having identified areas of need for improvement it is next essential to identify the drivers for low information quality code usage. There are a number of factors, along with code system structure, that could also be impacting upon the resulting information quality of the coded QHAPDC dataset. Generation of a coded dataset is a multistage process with many inputs, and each of these can potentially introduce error or a reduction in the information quality of the resulting data. Broadly, key factors in the data collection and generation process include: code system structure, aspects of the coding process (translating written information into coded data), and accuracy and completeness of source clinical documentation.

Examining the frequency and nature of assigned Falls and Transport-related codes it is apparent that the classification system, as currently constructed, does not reflect the epidemiology of treated patients. Thereby, code system structure may be impacting upon the information quality of information quality of the resulting coded records. Falls code sections contain relatively sparse options, yet the assigned codes within QHAPDC tend to be of relatively high information quality. This may be due to limited, but appropriate code options available within the code system. Contrastingly, the transport-related code section may be too complex, containing a large number of superfluous code options, and forcing the use of more generic codes due to a lack of more appropriate options to describe the unique causes of injury. The pre-coordinated format of the many codes resulting in inappropriate combinations of elements and forces use of less informative codes (i.e., one aspect of code prevents assignment, whereas other aspects appropriate). A multi-axial approach to classification system structure could potentially address this issue. It may be that Falls related injuries have more limited and consistent circumstances and thereby require fewer code options, or tend to have more detailed information contained within source documentation.

Coding issues, such as inaccurate code assignment can result in the degradation of coded information quality. This may be as a result of inadequate coding rules and guidance, inappropriate coding practices, or insufficient training and quality audit processes. Interventions to address inappropriate coding practice and additional education may be required to remedy these causes. Additionally, documentation issues, such as a lack of reliable evidence contained within the clinical documentation to support assignment of more detailed and informative codes can result in the forced use of poor information quality codes. If this is the case, improvement in source documentation completeness and accuracy would need to be achieved before benefits from improvements in codes system structure could be realised.

A study by McKenzie, Enraght-Moony, Harding, Walker, Waller & Chen, (2008) surveyed hospital-based clinical coders within Australia as to their informed opinions regarding the causes of error in external cause of injury hospital morbidity data collections. Coders ranked missing external cause of injury information within documentation as having the greatest impact on external cause coding. Notably, lack of specific codes within the code system and insufficient coder education were believed to have much smaller impacts on the quality of ICD-10-AM coded external cause of injury data, ranking 6th and 11th, respectively.

The quality of information within clinical documentation also ranked highest when survey respondents were asked to identify ways to improve external cause coding within hospital data. Whilst emergency department notes were ranked as the second highest quality documentation source for external cause of injury information (35% rated as a Good source of information; scale = 'No information' to 'Good information'), improving the quality of emergency department documentation was ranked as having the greatest influence on improving the quality of external cause of injury data. Eighty-five percent of respondents believed that improving the quality of emergency department documentation would have a high impact on increasing the quality of hospital morbidity data collections for injury causation (McKenzie et al., 2008). Notably, clinical coders identified the best source of external cause of injury information to be ambulance report forms, with 57% of survey respondents ranking this as a 'Good' source. Ambulance records were also ranked highest for place and activity related information.

Based upon the results of the Australian study of clinical coders (McKenzie et al., 2008), a key strategy to investigate for the quality enhancement of hospital external cause of injury data is the improvement of information within source clinical documentation. Clinical coders identify ambulance records as currently being the highest quality source of information. This finding requires validation based upon examination of a sample of clinical records for injury cases. Ambulance services hold a unique position, at patient handover, as the clinical interface between the community and the emergency department for acute events such as hospitalised injury. During the handover process, between the ambulance crew and receiving clinicians at hospital, it is standard practice (in Qld and developed emergency medical services internationally) that a copy of the ambulance clinical documentation is provided. This documentation becomes a part of the patient's clinical chart at hospital. If examination of injury case records supports the assertion that ambulance records are the highest quality source of external cause of injury information, including environment and activity information, this presents a key opportunity to develop a unique collection of injury information. Means to greater integrate this data source in to the hospital chart, to improve the quality of emergency department notes and the entire clinical record, should then be explored.

It is first necessary to undertake a detailed examination of Queensland hospital records to form an evidence-base regarding the causes of poor information quality within the current data collection, in order to develop a continuum of quality external cause of injury information in Queensland. To achieve this, a detailed chart review methodology is required to benchmark the available relevant information within the source documentation, and evaluate, at each point of processing, the translation of this information into coded data to identify applicable sources of error. Once this has been undertaken appropriate, evidence based, strategies to specifically address the identified sources of error can then be developed.

CHAPTER 6. MEDICAL RECORD REVIEW (Study3)

6.1 *Background*

Study 2 identified a number of priority areas for further investigation with regards to the fit-for-purpose nature of the hospital data collection. A number of contributing factors potentially impacted upon the quality of the coded QHAPDC data. Factors such as the level of detail contained in clinical documentation, code system complexity, and coder error all potentially impact upon the code assignment and resulting data quality. The contribution of these factors to the resulting coded data cannot be determined without detailed review of the source clinical documentation.

The final study of this dissertation (Study 3), involves a detailed on-site medical record review by an expert clinical coder. The record review process specifically focuses on measuring the impact of coder error on information attrition in the coded dataset; the loss of information quality due to code system constraints; and, the quality and availability of information in clinical documentation sources to support more detailed coding. The contribution of Study 3 to the overall program of research is displayed in **Figure 13**.

Within this study, specific focus is placed on examining ambulance report forms for external cause of injury information, and evaluating the capacity for this documentation source to be more fully utilised to increase the precision of the in-hospital coding process for cases transported by ambulance. Ambulance report forms present a unique and potentially valuable data source for injury information.

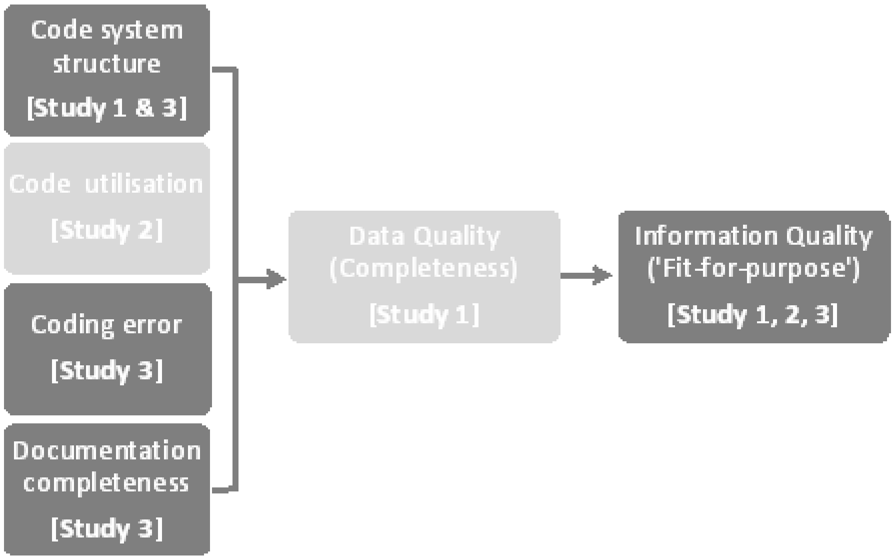

Figure 13 Study 3 Contribution to the overall program of research

The methodology for this recoding review was based upon the established Australian Coding Benchmark Audit (ACBA) record review methodology, and is similar to that used in a study by Langlois et al (1995) (Langlois et al., 1995b) to investigate the quality of clinical documentation for coding of external cause of injury information. However, this study is the first to use a medical record review methodology to examine the impact of the quality of source documentation upon the precision of ICD-10-AM external cause coding, and to employ a single evaluation framework to measure the 'fit-for-purpose' of all three key aspects of the clinical coding process (source documentation, code assignment and code system structure) for injury prevention.

6.2 *Objectives*

The key objectives of this study were to use the Haddon's framework described in Study 1:

a. To quantify the contribution of error sources in the coding process (i.e. code assignment error, documentation deficiencies, code system deficiencies) to information quality attrition in the coded dataset; and,

b. To measure the impact of ambulance documentation on the information quality of the resulting coded hospital morbidity dataset.

6.2.1 Research Questions

Specific research questions for this study were:

1. To what extent do code assignment errors contribute to:

   a) loss of information regarding a Haddon's element in the coded dataset?

   b) introduction of false information about a Haddon's element in the coded dataset?

2. What is the level of documentation sufficiency (conceptualised as coverage of Haddon's matrix elements), to support detailed coding of external cause of injury factors? Are there particular code blocks, injury mechanisms, or Haddon's elements for which documentation is particularly lacking pertinent information required to inform Haddon's matrix?

3. To what extent do insufficiencies within the ICD-10-AM code system contribute to information attrition in the coded dataset (compared to the base information quality level of the source documentation)? Are there key areas

where clinical documentation could currently support a more detailed code structure?

4. What is capacity of prehospital records to provide relevant injury causation details to enhance in-hospital data collections? To what extent does the presence of an ambulance record in the hospital chart contribute to the information quality of the overall source documentation for external cause of injury?

6.3 *Methods*

6.3.1 Procedure

A retrospective record review methodology was used to examine the clinical documentation of hospitalised patients with an injury-related diagnosis. The random sample of hospital records was selected from all acute care admissions with at least one assigned external cause code (V01-Y98) and record of an injury-related diagnosis (S00-T79) between 1 July 2002 and 30 June 2003.

6.3.2 Selection of Hospital Sample

The study included a stratified random sample of 12 hospitals across the state of Queensland. Sample selection for this study within Queensland hospitals was conducted as part of a larger national study (McKenzie K, Enraght-Moony E, Walker S, McClure R, & Harrison J, 2009a; McKenzie et al., 2009). The process for selection of the sample is described below.

6.3.3 Exclusion Criteria

2002/03 national hospital morbidity data were analysed by establishment ID to identify the percentage each establishment contributed to the national injury caseload. In 2002-03 there were a little over 400,000 injury separations from 448 hospitals across four states of Australia. Of these, 220 hospitals reported fewer than 200 injury separations each, these amounting to less than 5% of the total injury caseload. These 220 were excluded from the stratification process. In addition, two hospitals in remote locations were excluded from the sampling process as resource constraints prevented the inclusion of these hospitals in the sample. This resulted in a sampling frame of 226 hospitals across Australia available for selection of the final hospital sample.

6.3.3.1 **Stratification and Sampling Process**

1. The 226 hospitals were stratified according to the following elements:

    a. Locality (ASGC remoteness) - Urban, Regional (incl. inner and outer).

    b. Number of injury separations during 2002/03 financial year - Large >2500 cases per annum, Medium 1000-2499 cases per annum, Small <1000 cases per annum.

2. To ensure that hospitals which contribute the most to hospitalisation injury data estimates were included in the sample, a sampling fraction was employed to weight the strata according to the injury caseload size. Large hospitals were weighted with a sampling fraction of 0.66, medium hospitals were weighted with a sampling fraction of 0.30, and small hospitals were weighted with a sampling fraction of 0.03 to reflect the proportion each contributed to overall injury admissions.

3. A simple random sample within each of the six strata was obtained using these weights, resulting in a sample of 12 hospitals being drawn from the population of hospitals across Queensland.

6.3.3.2 **Sample Size – Number of records**

Sample size for the number of medical records to be audited was determined by a number of factors, including sampling requirements, budget and resources for the national ARC-funded project of which this thesis was a part. As there were no studies available that measure the quality of ambulance records for external cause of injury information, and the subsequent statistical analyses in this study are multifactorial, (thereby increasing the numbers needed for statistical analysis) it was difficult to estimate the sample size required for sufficient statistical power. The hospital sample consisted of 12 hospitals across the state, stratified by injury caseload. Based upon feasibility calculations (cost of salaries, accommodation, impact on hospital staff), it was estimated that an average of 100 records could be sampled at each hospital site (depending on the percentage injury caseload the hospital contributes), resulting in a sample of approximately 1200 records.

6.3.3.3 **Data Collection Process**

Once suitable hospitals had been identified as eligible for the study, Health Information Managers responsible for the Health Record Departments at each hospital were approached to indicate their willingness 'in principle' to participate in the study. Following consent of the Health Information Managers, and acquisition of appropriate ethical approvals, the Health Statistics Centre (Qld Health) was contacted to extract a random sample of injury cases from the selected hospital sample. The Health Statistics Centre allocated a unique project ID to each record and an identified list of records was to each hospital to enable the medical charts to be pulled for review. A de-identified list of records for review was sent to the researchers (with unique project ID).

The medical records reviews were conducted on-site by an expert clinical coder employed using funding from the ARC grant, who attended each hospital site in the sample and audited records (this person will be referred to for the remainder of this thesis as the 'auditor'). The auditor then used a custom-designed data collection form to recode all selected records. This form blinded the Auditor to the ICD codes assigned by the original clinical coder (see **Appendix 6**: Medical Record Review data collection forms). The new codes, assigned by the auditor were recorded on the front sheet of data collection forms, and the auditor also collected 'verbatim' the narrative descriptions of external cause of injury factors from the medical record sources.

To preserve confidentiality the data collection forms had no identifiable information on them, bar the unique project ID which researchers could to match to the electronic datafile received from the Health Statistics Centre (Qld Health). Each form contained a prompt on both the front and back reminding the Auditor to check the patients unique record number (URN) and other identifying details and make sure the correct person's records had been retrieved. The auditor had access to a master list at the hospital with the project ID and patient URN, to ensure the correct record was audited. This master list was retained by the hospital.

6.3.3.4 **Data Collection Tools**

A proforma was developed to abstract information from the medical records in a standardised procedure. The record review process was based upon the Australian Coding Benchmark Audit (ACBA) procedure, which is a coding audit method that involves re-coding a sample of hospital-admitted patient episodes, and uniformly recording the results. The ACBA was developed by NCCH, and has been utilised in several localities and hospital settings across Australia. However, as the focus of the project is external cause of injury, the procedure was modified to address only those codes during the audit process.

Information was extracted from both hospital and ambulance service clinical records, including narrative descriptions of the external cause of injury, place of occurrence, and activity at time of injury. For each piece of extracted information, the source documentation was recorded (ie. hospital record; Ambulance Report Form). Based upon the abstracted external cause of injury information in the medical records, and assigned diagnosis and procedure codes for the hospital records, the auditor recoded the sampled medical records using the ICD-10-AM Chapter XX (External Causes of Morbidity and Mortality). The auditor was blinded to the original external cause codes assigned to the record.

As one of the aims of the medical record data collection phase was to assess reasons for a lack of precision in the data (i.e. documentation deficiencies, error in code assignments, classification limitations etc), agreement between the original ICD-10-AM external cause codes and the reviewed codes was analysed, and reasons for any differences were explored. To assess accuracy of the original coding process, the Haddon's matrix evaluation framework was used to compare the codes assigned during the review process with those assigned by the original coder. Place of Occurrence and Activity codes assigned during the review process were compared with those on the original hospital coded record.

Secondly, to assess the impact of ambulance documentation on the quality of coding, the narrative information retrieved from ambulance versus hospital documentation sources was compared using the Haddon's matrix framework to identify the level of specific information between sources, and the impact of the 'fit-for-purpose' of information sources on the precision of coding.

6.4 *Ethical Clearance*

As Queensland Health did not have a centralized ethical clearance procedure at the time of this study, ethical clearance had to be sought from both the state health department and each individual hospital at which access to records was required. No hospitals selected in the sample refused ethical clearance for the project (see **Appendix 7** for a copy of the ethical approval from QH).

6.5 *Data Preparation*

The Haddon's matrix categorisations for the entire ICD-10-AM external cause of injury code set, developed in Study 1 of this thesis, were merged to the Original and Auditor assigned external cause codes within the medical record review dataset. This enabled the Haddon's evaluation framework to be employed to evaluate the information quality, and therefore any differences in information quality, between the Original and the Auditor assigned ICD-10-AM codes.

The impact of documentation was measured by an auditor extracting pertinent textual information from a sample of hospital and ambulance case documentation. The retrieved narratives were categorised using the Haddon's evaluation framework employed in Studies 1 and 2 of this thesis, to identify the coverage of key Haddon's injury elements within the clinical documentation sources. Coverage levels were compared between the unconstrained narrative accounts and the resultant coded representations to identify any 'information quality' attrition as a consequence of the coding process. The narrative accounts of each injury case, retrieved by the Auditor from the individual documentation sources, were manually categorised for Presence/Absence of Haddon's element (Host, Mechanism/Object, Vector/Perpetrator, Environment). This categorisation was performed independently by the student and another researcher for accuracy. A customised Microsoft Access Database was developed by the Chief Investigator for the larger project for this purpose. In the case of discrepancies in categorisation a consensus agreement was reached between the two researchers.

The information quality of the assigned external cause codes was compared to the information quality of the unconstrained narrative source documentation, to measure information attrition.

6.6 *Analysis*

Statistical analyses were performed to identify the:

a. contribution of coder error to loss of information/false information within the coded data measured using Haddon's matrix;

b. sufficiency of the source documentation in terms of the ability of the clinical documentation sources to inform Haddon's matrix, to identify mechanisms where documentation lacks information required for detailed code assignment [information deficiency];

c. information attrition in the coded dataset due to code insufficiency; and

d. utility of ambulance records to provide relevant injury causation details and enhance hospital data collections.

The above analyses were performed in the following ways:

1. Contribution of coder error to loss of information/false information within the coded data. (Table 35)

Agreement between the Original Coder & the Auditor was calculated via a 2x2 matrix, with the Auditor considered to be the 'proxy gold standard' for comparison.

Percentage of original coder error was quantified as:

$$\frac{N\ [\textit{false negatives + false positives}]}{N\ [\textit{Total codes in code block}]} * 100$$

Table 35 Coder Error Calculation

		Auditor Code	
		Haddon's Present	Haddon's Absent
Original Code	Haddon's Present	Completeness of Coverage	False Positives
	Haddon's Absent	False Negatives	Specificity
		Total P	Total A

2. Sufficiency of the source documentation in terms of the ability of the clinical records to inform Haddon's matrix. (Table 36)

The extent of available information within each documentation source [Total P] was calculated for each Haddon's element by injury mechanism. The percentage of Haddon's Present/Absent for each Haddon's element by injury mechanism is presented using the International ICD results presentation matrices, as used in Studies 1 & 2 of this thesis.

Table 36 Documentation Sufficiency Calculation

		Narrative text	
		Haddon's Present	Haddon's Absent
Audited Code	Haddon's Present	Sensitivity	False Positives
	Haddon's Absent	False Negatives	Specificity
		Total P	Total A

The extent of missing information in documentation sources [Total A] was calculated to highlight blocks where improvement is documentation is required as insufficient information is available to support more detailed code assignment.

3. Information attrition due to coding process was measured by false negative rates [FN]. (Table 37)

Retrieved narratives were categorised using the Haddon's evaluation framework employed in Studies 1 and 2 of this thesis. To identify the coverage of key Haddon's injury elements within the clinical documentation sources, coverage levels were compared between the unconstrained narrative accounts and the resultant coded representations to identify any 'information quality' attrition as a consequence of the coding process.

The information quality of the assigned external cause codes was compared to the information quality of the unconstrained narrative source documentation, to measure information attrition. False negatives in the audited codes (proxy gold standard) indicates that information is present in the clinical documentation but detailed ICD-10-AM codes are not available within the code system to accurately capture the details.

Table 37 Information Attrition Calculation

		Narrative text	
		Haddon's Present	Haddon's Absent
Audited Code	Haddon's Present	Sensitivity	False Positives
	Haddon's Absent	False Negatives	Specificity
		Total P	Total A

4. Utility of ambulance and hospital records for injury information.

The impact of documentation was captured by an expert clinical coder extracting pertinent textual information from a sample of hospital and ambulance case documentation. The retrieved narratives were categorised using the Haddon's evaluation framework employed in Studies 1 and 2 of this thesis. To compare the coverage of key Haddon's injury elements within each clinical documentation source, Haddon's element 'Present' levels were compared between clinical documentation sources by each Haddon's element (Host, Agent, Mechanism, and Environment).

The contribution of presence of an ambulance record to information quality was reported in terms of effect size, which measures the strength of association between existence of an ambulance record and the presence of each of the Haddon's elements in the coded data. Unadjusted comparisons of categorical variables were conducted using Fisher's exact chi square test. Crude measures of association between variables were calculated using Pearson Correlations (R^2).

Adjusted measures of association were developed using multivariable logistic regression to measure the contribution of prehospital documentation, and other to the coding process, for each Haddon's element. An assumption of independence was made for each dependent variable. Nagelkerke's R^2, a version of the Cox & Snell R-square that adjusts the scale of the statistic to cover the full range from 0 to 1, was used as a measure of effect. Odds ratios were also provided with the logistic regression output as an additional measure of effect size.

The hypotheses for the logistic regressions were:

H0: The presence of an ambulance record in the hospital medical chart is not independently associated with an increased presence of injury information in the coded data.

H1: The presence of an ambulance record in the hospital medical chart is independently associated with an increased presence of injury information in the coded data.

Significance level was set at $p<.05$ criterion for all analyses. Statistical analysis performed using Statistical Package for Social Scientists (V19).

The categorical codings that were used with all categorical variables entered into the logistic regression models are listed in Tables 38 and 39:

Table 38 Logistic regression categorical codings - DVs

Dependent Variable	
Original Value	Internal Value
Absent	0
Present	1

Table 39 Logistic regression categorical codings - IVs

Categorical Variables Codings							
			Parameter coding				
		Frequency	(1)	(2)	(3)	(4)	(5)
Fifteen year age groups	0-14	378	.000	.000	.000	.000	.000
	15-29	316	1.000	.000	.000	.000	.000
	30-44	210	.000	1.000	.000	.000	.000
	45-59	117	.000	.000	1.000	.000	.000
	60-74	55	.000	.000	.000	1.000	.000
	75+	82	.000	.000	.000	.000	1.000
Injury Mechanism	Transport	182	.000	.000			
	Fall	328	1.000	.000			
	Other	648	.000	1.000			
Hospital size	Large	960	.000				
	Medium	198	1.000				
Sex	Male	757	.000				
	Female	401	1.000				
Arrival Mode	Not BIBA	769	.000				
	BIBA	389	1.000				
Hospital locality	Urban	675	.000				
	Regional	483	1.000				

6.7 *Results*

6.7.1 Sample Descriptives

Of the cases reviewed (n=1,158), the vast majority (82.9%) of cases were from large hospitals (>2,500 injury admissions/year), and over half of the cases (58.3%) were from hospitals in urban locations. Patients had a mean length of stay of 2.6 days, and approximately 9 out of 10 patients were discharged to 'Other' (i.e. private residence) at the end of their hospitalisation. Two-thirds of patients were male, and the age distribution was skewed towards younger age groups; 59.9% were between the ages of 0 and 29 years. Case descriptives for all reviewed records are presented in **Table 40.**

Table 40 Descriptives of sample in medical record review

		N	%
Hospital Locality	Urban	675	58.3
	Regional	483	41.7
Hospital Size	Large	960	82.9
	Medium	198	17.1
Sex	Male	757	65.4
	Female	401	34.6
Separation Mode	Discharge/transfer to an(other) acute hospital	90	7.8
	Discharge/transfer to a nursing home	3	0.3
	Discharge/transfer to other healthcare accom	7	0.6
	Statistical discharge – type change	15	1.3
	Left against medical advice/discharge	9	0.8
	Died	6	0.5
	Other	1028	88.8
Age Group	0-14	378	32.6
	15-29	316	27.3
	30-44	210	18.1
	45-59	117	10.1
	60-74	55	4.7
	75+	82	7.1
Length of Stay*		1158	*2.6 (± 5.408)

**mean (standard deviation)*

One-third of patients (33.6%; n=389) arrived at hospital by ambulance (BIBA). Case characteristics for patients arriving at hospital by ambulance (BIBA) were compared with those of patients arriving by other means (Not BIBA). Unadjusted analyses showed statistically significant differences between ambulance patients and non-ambulance patients. A greater percentage of patients arriving by ambulance were women (39% BIBA vs 32% Not BIBA), had suffered transport-related injuries (20% BIBA vs 14% Not BIBA) and fewer 'Other' injuries (50% BIBA vs 59% Not BIBA), were skewed towards the older age groups, and had longer lengths of stay in hospital (p<.05) (see **Table 41**).

Table 41 Sample Characteristics – Arrival Mode

		BIBA		NOT BIBA		TOTAL		$\chi 2$	p
		N	%	N	%	N	%		
Hospital Locality	Urban	235	35	440	65	675	100		
	Regional	154	32	329	68	483	100	1.084	p>.05
Hospital Size	Large	321	33	639	67	960	100		
	Medium	68	34	130	66	198	100	0.06	p>.05
Sex	Male	237	31	520	69	757	100		
	Female	152	38	249	62	401	100	5.115	p<.05
Separation Mode	Discharge/transfer to an(other) acute hospital	29	32	61	68	90	100		
	Discharge/transfer to a nursing home	1	33	2	67	3	100		
	Discharge/transfer to other health care accommodation	3	43	4	57	7	100		
	Statistical discharge – type change	8	53	7	47	15	100		
	Left against medical advice/discharge at own risk	6	67	3	33	9	100		
	Died	4	67	2	33	6	100		
	Other (Discharged home)	338	33	690	67	1028	100	0.168	p>.05
Age Group	0-14	87	23	291	77	378	100		
	15-29	111	35	205	65	316	100		
	30-44	69	33	141	67	210	100		
	45-59	43	37	74	63	117	100		
	60-74	29	53	26	47	55	100		
	75+	50	61	32	39	82	100	56.453	p<.05
Injury Mechanism	Transport	78	43	104	57	182	100		
	Fall	117	36	211	64	328	100		
	Other	194	30	454	70	648	100	11.517	p<.05
Length of Stay*		389	*3.32 (±7.838)	769	*2.23 (±3.554)	t(470)= -2.610; p<.05			

*mean (standard deviation)

6.7.2 Code Assignment Errors

RQ1. To what extent do code assignment errors contribute to:

a) Loss of information regarding a Haddon's element in the coded dataset?

b) Introduction of false information about a Haddon's element in the coded dataset?

The following table (**Table 42**) presents the overall error rates (combined across injury mechanism code blocks) associated with the coding process. The figures presented are as a percentage of all assigned codes where Original and Audited codes differed, and the resulting codes varied as to the presence of information regarding a Haddon's element. Notably, for Environment information variation between the Original and Audited codes resulted in a change of assignment between 'Present' and 'Absent' for 15% of cases. The category where concordance was highest between Original and Audited codes was for Mechanism/Object information in Falls cases (1% error rate). Across all injury mechanisms, coding error rates averaged between 5% and 8% for each of the Haddon's elements. These coding errors may have resulted in the introduction of false information (False positive) or the loss of information (False negative).

Table 42 Overall Error Rates Associated with the Coding Process

	ALL INJURIES	TRANSPORT	FALLS
Host	5%	4%	2%
Mechanism	6%	9%	1%
Object/Perpetrator	8%	2%	8%
Environment	7%	8%	15%

Table 43 presents for each Haddon's element by key injury group, a more detailed breakdown of the rates of false positives and false negatives as a result of variations between Original and Audited codes.

False positives (introduction of false information in the Original code) were notable amongst 'Other' injury cases for Mechanism and Object information. In both categories approximately one-quarter of cases where the audited code did not contain mechanism or object information the original code had introduced unsubstantiated details (False positive; Type I error). Conversely, original codes for 'Other' injury cases omitted available Host information (False negative; Type II error) in 11% of cases where the audited code had captured this information. Environment information had high levels of both false negatives and false positives comparing original and audited codes. Approximately one-fifth of original Transport-related codes and a tenth of Falls codes contained false Environment information in the original codes. Notably, original assigned Falls codes also had high levels (20%) of false negatives, lost information, for environment; as did the 'Other' injuries group (17%).

Table 43 Overall Error Rates between Original and Audited Codes

				Auditor Code (Gold Standard)				
				Present	Absent	Total	False +ve	False -ve
HOST	**All Injury**	**Original Code**	Present	383	29	412		
			Absent	32	714	746		
			Total	415	743	1158	0.04	0.08
	All Transport	**Original Code**	Present	172	3	175		
			Absent	4	3	7		
			Total	176	6	182	0.50	0.02
	Fall	**Original Code**	Present	1	5	6		
			Absent	1	321	322		
			Total	2	326	328	0.02	0.50
	Other	**Original Code**	Present	210	21	231		
			Absent	27	390	417		
			Total	237	411	648	0.05	0.11
MECHANISM	**All Injury**	**Original Code**	Present	1067	16	1083		
			Absent	29	46	75		
			Total	1096	62	1158	0.26	0.03
	All Transport	**Original Code**	Present	177	0	177		
			Absent	4	1	5		
			Total	181	1	182	0.00	0.02
	Fall	**Original Code**	Present	325	0	325		
			Absent	3	0	3		
			Total	328	0	328	N/A	0.01
	Other	**Original Code**	Present	565	16	581		
			Absent	22	45	67		
			Total	587	61	648	0.26	0.04
OBJECT/PERPETRATOR	**All Injury**	**Original Code**	Present	1070	15	1085		
			Absent	27	46	73		
			Total	1097	61	1158	0.25	0.02
	All Transport	**Original Code**	Present	177	0	177		
			Absent	4	1	5		
			Total	181	1	182	0.00	0.02
	Fall	**Original Code**	Present	325	0	325		
			Absent	3	0	3		
			Total	328	0	328	N/A	0.01
	Other	**Original Code**	Present	568	15	583		
			Absent	20	45	65		
			Total	588	60	648	0.25	0.03
ENVIRONMENT	**All Injury**	**Original Code**	Present	273	46	319		
			Absent	40	799	839		
			Total	313	845	1158	0.05	0.13
	All Transport	**Original Code**	Present	155	3	158		
			Absent	11	13	24		
			Total	166	16	182	0.19	0.07
	Fall	**Original Code**	Present	113	20	133		
			Absent	28	167	195		
			Total	141	187	328	0.11	0.20
	Other	**Original Code**	Present	5	23	28		
			Absent	1	619	620		
			Total	6	642	648	0.04	0.17

6.7.3 Code System Limitations

RQ2.To what extent do insufficiencies within the ICD-10-AM code system contribute to information attrition in the coded dataset (compared to the base information quality level of the source documentation)? Are there key areas where clinical documentation could currently support a more detailed code structure?

Concordance between the availability of information within the clinical documentation and the audited code was examined through cross-tabulation and calculation of false negative rates. (see **Table 44**) A loss of information (Type II error) is evident in the process of translating narrative details from the medical record into coded form. The highest level of false negatives was for Environment information. Across all injury mechanisms, where Environment information had been identified as available within the clinical documentation, in 68% of cases this was absent from the audited code. This was predominantly due to Falls cases (false negatives = .51) and Other injury cases (false negatives = 0.98). There were also high false negative rates amongst Falls cases and Other injury cases for Host information (.99 and .58, respectively). Comparatively, Transport cases had low false negative rates across all Haddon's elements (<.10).

6.7.4 Documentation Sufficiency

RQ3. What is the level of documentation sufficiency (conceptualised as coverage of Haddon's matrix elements), to support detailed coding of external cause of injury factors? Are there particular code blocks, injury mechanisms, or Haddon's elements for which documentation is particularly lacking pertinent information required to inform Haddon's matrix?

Manual review of the entire hospital medical chart identified that Host information was available somewhere in the medical documentation in 74% of all injury cases. Mechanism information was most prevalent (98% of cases), followed by Object information in 88% of records. Across all injury types, documentation of

Environment information was poorest (54%). Documentation sufficiency varied by injury type for each Haddon's element, with availability of Environment information ranging from 49% for 'Other' injuries to 60% for Falls cases. Likewise, Host information ranged from 58% in Falls cases to 85% for Transport-related injuries, and Object information was best documented for Transport-related cases (100%) and least documented for Falls (79%) (see **Table 44**).

Table 44 Code System Limitations & Documentation Sufficiency

				In Documentation				
				Present	Absent	Total	False +ve	False -ve
HOST	**All Injury**	**Audited Code**	Present	351	64	415		
			Absent	474	269	743		
			Total	825	333	1158	**0.19**	0.57
	All Transport	**Audited Code**	Present	149	27	176		
			Absent	5	1	6		
			Total	154	28	182	**0.96**	0.03
	Fall	**Audited Code**	Present	2	0	2		
			Absent	188	138	326		
			Total	190	138	328	**0.00**	0.99
	Other	**Audited Code**	Present	200	37	237		
			Absent	281	130	411		
			Total	481	167	648	**0.22**	0.58
MECHANISM	**All Injury**	**Audited Code**	Present	1088	8	1096		
			Absent	46	16	62		
			Total	1134	24	1158	**0.33**	0.04
	All Transport	**Audited Code**	Present	181	0	181		
			Absent	1	0	1		
			Total	182	0	182	**N/A**	0.01
	Fall	**Audited Code**	Present	326	2	328		
			Absent	0	0	0		
			Total	326	2	328	**1.00**	0.00
	Other	**Audited Code**	Present	581	6	587		
			Absent	45	16	61		
			Total	626	22	648	**0.27**	0.07
OBJECT/PERPETRATOR	**All Injury**	**Audited Code**	Present	996	101	1097		
			Absent	23	38	61		
			Total	1019	139	1158	**0.73**	0.02
	All Transport	**Audited Code**	Present	181	0	181		
			Absent	1	0	1		
			Total	182	0	182	**N/A**	0.01
	Fall	**Audited Code**	Present	259	69	328		
			Absent	0	0	0		
			Total	259	69	328	**1.00**	0.00
	Other	**Audited Code**	Present	556	32	588		
			Absent	22	38	60		
			Total	578	70	648	**0.46**	0.04
ENVIRONMENT	**All Injury**	**Audited Code**	Present	201	112	313		
			Absent	426	419	845		
			Total	627	531	1158	**0.21**	0.68
	All Transport	**Audited Code**	Present	99	67	166		
			Absent	9	7	16		
			Total	108	74	182	**0.91**	0.08
	Fall	**Audited Code**	Present	97	44	141		
			Absent	102	85	187		
			Total	199	129	328	**0.34**	0.51
	Other	**Audited Code**	Present	5	1	6		
			Absent	315	327	642		
			Total	320	328	648	**0.00**	0.98

Crude analysis was undertaken to identify factors associated with documentation completeness for each of the Haddon's elements. A number of significant associations were identified for each element. The presence of Host information in clinical documentation differed significantly by hospital locality and size, patient sex and age, injury type and arrival mode at hospital. Patients with Host information available in their medical records were more likely to have been treated at a large, urban hospital for transport-related injuries, to be middle-aged and male, and to have arrived at hospital by ambulance. (**Table 45**)

Table 45 Documentation Completeness by Host

HOST		Documented		Not Documented		TOTAL		$\chi2$	p
		N	%	N	%	N	%		
Hospital Locality	Urban	497	74	178	26	675	100		
	Regional	328	68	155	32	483	100	4.497	p<.05
Hospital Size	Large	699	73	261	27	960	100		
	Medium	126	64	72	36	198	100	6.746	p<.05
Sex	Male	564	75	193	25	757	100		
	Female	261	65	140	35	401	100	11.348	p<.05
Age Group	0-14	225	60	153	40	378	100		
	15-29	256	81	60	19	316	100		
	30-44	172	82	38	18	210	100		
	45-59	91	78	26	22	117	100		
	60-74	36	65	19	35	55	100		
	75+	45	55	37	45	82	100	65.771	p<.05
Injury Mechanism	Transport	154	85	28	15	182	100		
	Fall	190	58	138	42	328	100		
	Other	481	74	167	26	648	100	47.094	p<.05
Arrival Mode	BIBA	317	81	72	19	389	100		
	Not BIBA	508	66	261	34	769	100	30.025	p<.05

Mechanism of injury information was more present in the clinical documentation for patients arriving at medium sized and urban hospitals by ambulance for transport and fall-related injuries. (**Table 46**) However, patient sex and age group did not have a significant association with the presence of Mechanism information.

Table 46 Documentation Completeness by Mechanism of Injury

MECHANISM		Documented		Not Documented		TOTAL		χ2	p
		N	%	N	%	N	%		
Hospital Locality	Urban	667	99	8	1	675	100		
	Regional	467	97	16	3	483	100	6.278	p<.05
Hospital Size	Large	936	98	24	3	960	100		
	Medium	198	100	0	0	198	100	5.055	p<.05
Sex	Male	741	98	16	2	757	100		
	Female	393	98	8	2	401	100	0.018	p>.05
Age Group	0-14	373	99	5	1	378	100		
	15-29	310	98	6	2	316	100		
	30-44	203	97	7	3	210	100		
	45-59	115	98	2	2	117	100		
	60-74	53	96	2	4	55	100		
	75+	80	98	2	2	82	100	3.532	p>.05
Injury Mechanism	Transport	182	100	0	0	182	100		
	Fall	326	99	2	1	328	100		
	Other	626	97	22	3	648	100	12.894	p<.05
Arrival Mode	BIBA	386	99	3	1	389	100		
	Not BIBA	748	97	21	3	769	100	4.888	p<.05

Object information relating to the injury event was more often available in the clinical records of patients treated at medium-sized and urban hospitals. Again, patients were more likely to have been hospitalised for transport-related injuries and to have been transported to hospital by ambulance. (**Table 47**)

Table 47 Documentation Completeness by Object/Perpetrator

OBJECT/PERPETRATOR		Documented		Not Documented		TOTAL		χ2	p
		N	%	N	%	N	%		
Hospital Locality	Urban	603	89	72	11	675	100		
	Regional	421	87	62	13	483	100	1.295	p>.05
Hospital Size	Large	840	88	120	13	960	100		
	Medium	184	93	14	7	198	100	4.729	p<.05
Sex	Male	689	91	68	9	757	100		
	Female	335	84	66	16	401	100	14.318	p<.05
Age Group	0-14	345	91	33	9	378	100		
	15-29	291	92	25	8	316	100		
	30-44	187	89	23	11	210	100		
	45-59	104	89	13	11	117	100		
	60-74	43	78	12	22	55	100		
	75+	54	66	28	34	82	100	53.705	p<.05
Injury Mechanism	Transport	182	100	0	0	182	100		
	Fall	259	79	69	21	328	100		
	Other	583	90	65	10	648	100	54.036	p<.05
Arrival Mode	BIBA	357	92	32	8	389	100		
	Not BIBA	667	87	102	13	769	100	6.407	p<.05

The presence of Environment information in the medical records was significantly associated with urban hospitals, older-aged patients and fall-related injuries (**Table 48**). Arrival mode at hospital was statistically significant, with patients arriving at hospital by ambulance more often having Environment information recorded in their medical documentation (89% vs 36%)

Table 48 Documentation Completeness by Environment

ENVIRONMENT		Documented		Not Documented		TOTAL		χ2	p
		N	%	N	%	N	%		
Hospital Locality	Urban	394	58	281	42	675	100		
	Regional	233	48	250	52	483	100	11.637	p<.05
Hospital Size	Large	515	54	445	46	960	100		
	Medium	112	57	86	43	198	100	0.564	p>.05
Sex	Male	394	52	363	48	757	100		
	Female	233	58	168	42	401	100	3.874	p>.05
Age Group	0-14	204	54	174	46	378	100		
	15-29	163	52	153	48	316	100		
	30-44	101	48	109	52	210	100		
	45-59	61	52	56	48	117	100		
	60-74	34	62	21	38	55	100		
	75+	64	78	18	22	82	100	24.302	p<.05
Injury Mechanism	Transport	100	55	82	45	182	100		
	Fall	195	59	133	41	328	100		
	Other	312	48	336	52	648	100	11.708	p<.05
Arrival Mode	BIBA	347	89	42	11	389	100		
	Not BIBA	280	36	489	64	769	100	289.976	p<.05

6.7.5 Ambulance Records

RQ4. What is the current capacity of prehospital records to provide relevant injury causation details to enhance inhospital data collections? To what extent does the presence of an ambulance record in the hospital chart contribute to the information quality of the overall source documentation for external cause of injury?

Unadjusted analyses identified statistically significant relationships between a patient being transported to hospital by ambulance and the presence in the medical records of injury information relating to each of the Haddon's elements. Further analysis was conducted to quantify the relationship between arrival mode and the level of injury information in documentation.

As displayed in **Table 49**, there was a statistically significant difference between the group of patients arriving to hospital by ambulance (BIBA) and those arriving by other means (Not BIBA) for Host information. [$\chi2$ (1) = 30.025, p<.05] The conditional probability of a case not brought in by ambulance (Not BIBA) having Host information present anywhere in the medical record was .66 (508/769), and for patients brought in by ambulance (BIBA) the conditional probability was .81 (317/389). Patients arriving by ambulance were 2.26 times [95% CI 1.071, 12.186] more likely to have Host information present than non-ambulance patients.

Table 49 Host Information by Arrival Mode

			Host		Total
			Absent	Present	
Arrival Mode	Not BIBA	Count	261	508	769
		% within Arrival Mode	34%	66%	100%
		% of Total	23%	44%	66%
	BIBA	Count	72	317	389
		% within Arrival Mode	19%	81%	100%
		% of Total	6%	27%	34%
Total		Count	333	825	1158
		% within Arrival Mode	29%	71%	100%
		% of Total	29%	71%	100%

Patients arriving to hospital by ambulance (BIBA) were also statistically more likely to have Mechanism information than those arriving by other means (Not BIBA). [$\chi2$ (1) = 4.888, p<.05] The presence of Mechanism information in the medical record had a conditional probability of .97 (748/769) for non-ambulance patients versus .99 (386/389) for patients brought in by ambulance. Patients arriving by ambulance were 3.62 times [95% CI 1.071, 12.186] more likely to have Mechanism information present than non-ambulance patients. (**Table 50**)

Table 50 Mechanism Information by Arrival Mode

			Mechanism		
			Absent	Present	Total
Arrival Mode	Not BIBA	Count	21	748	769
		% within Arrival Mode	3%	97%	100%
		% of Total	2%	65%	66%
	BIBA	Count	3	386	389
		% within Arrival Mode	1%	99%	100%
		% of Total	0%	33%	34%
Total		Count	24	1134	1158
		% within Arrival Mode	2%	98%	100%
		% of Total	2%	98%	100%

Likewise, a statistically significant difference was present for Object/Perpetrator information. [$\chi 2$ (1) = 6.407, $p<.05$] Patients arriving by ambulance were 1.71 times [95% CI 1.124, 2.590] more likely to have this information present than non-ambulance patients. The conditional probability of a case not brought in by ambulance (Not BIBA) having Object information present anywhere in the medical record was .87 (667/769), and for patients brought in by ambulance (BIBA) the conditional probability was .92 (357/389). (**Table 51**)

Table 51 Object/Perpetrator Information by Arrival Mode

			Object		
			Absent	Present	Total
Arrival Mode	Not BIBA	Count	102	667	769
		% within Arrival Mode	13%	87%	100%
		% of Total	9%	58%	66%
	BIBA	Count	32	357	389
		% within Arrival Mode	8%	92%	100%
		% of Total	3%	31%	34%
Total		Count	134	1024	1158
		% within Arrival Mode	12%	88%	100%
		% of Total	12%	88%	100%

A large effect of arrival mode was evidenced for Environment information. [$\chi 2$ (1) = 289.976, p<.05] Cases not brought in by ambulance (Not BIBA) had a conditional probability of .36 (280/769) for Environment information, compared to .89 (347/389) for ambulance patients. Patients arriving by ambulance were 14.43 times [95% CI 10.144, 20.523] more likely to have Environment information present than non-ambulance patients. (**Table 52**)

Table 52 Environment Information by Arrival Mode

			Environment		Total
			Absent	Present	
Arrival Mode	Not BIBA	Count	489	280	769
		% within Arrival Mode	64%	36%	100%
		% of Total	42%	24%	66%
	BIBA	Count	42	347	389
		% within Arrival Mode	11%	89%	100%
		% of Total	4%	30%	34%
Total		Count	531	627	1158
		% within Arrival Mode	46%	54%	100%
		% of Total	46%	54%	100%

Adjusted Analyses – Logistic Regression

Unadjusted analyses identified significant relationships between the information quality of clinical documentation for injury details and a number of hospital and patient characteristics. Regression analysis was conducted to measure the independent contribution of each factor to the quality of injury information in clinical documentation. The dependent variable which measures the presence of injury information in the clinical documentation is Haddon’s Element (Present; Absent). Haddon’s Element (Present; Absent) is equal to 1 if relevant information was identified in the clinical records and 0 otherwise. Since the dependent variable is categorical, a logistic regression model was used to estimate the factors which influenced documentation quality. A separate model was developed for each of the Haddon’s element (Host, Mechanism, Object, and Environment). All independent variables were entered into the equation in a forward stepwise manner.

Univariate analyses have identified a number of significant relationships between hospital, patient and system characteristics and the quality of clinical documentation for injury information. Bivariate correlations were calculated for all statistically significant independent variables to identify any significant covariances. A number of statistically significant correlations were identified (**Table 53**); in particular, arrival mode was significantly correlated with patient sex, age, injury type and length of stay ($p<.05$).

Table 53 Correlations between Independent Variables

		Hospital locality (numeric)	Hospital size (numeric)	Sex (numeric)	Five year age groups	Injury Mechanism for Log Reg	Arrival Mode	Length of stay
Hospital locality (numeric)	Pearson Correlation	1						
	Sig. (2-tailed)							
	N	1158						
Hospital size (numeric)	Pearson Correlation	.076	1					
	Sig. (2-tailed)	**.009**						
	N	1158	1158					
Sex (numeric)	Pearson Correlation	-.030	.070	1				
	Sig. (2-tailed)	.301	**.018**					
	N	1158	1158	1158				
Five year age groups	Pearson Correlation	.106	-.143	.112	1			
	Sig. (2-tailed)	**.000**	**.000**	**.000**				
	N	1158	1158	1158	1158			
Injury Mechanism for Log Reg	Pearson Correlation	.001	-.017	.016	-.072	1		
	Sig. (2-tailed)	.960	.552	.583	**.015**			
	N	1158	1158	1158	1158	1158		
Arrival Mode	Pearson Correlation	-.031	.007	.066	.208	-.100	1	
	Sig. (2-tailed)	.298	.806	**.024**	**.000**	**.001**		
	N	1158	1158	1158	1158	1158	1158	
Length of stay	Pearson Correlation	-.022	-.081	.011	.251	-.185	.095	1
	Sig. (2-tailed)	.450	**.006**	.703	**.000**	**.000**	**.001**	
	N	1158	1158	1158	1158	1158	1158	1158

A logistic regression model, using all statistically significant univariate factors, was developed to compare whether patients arriving at hospital by ambulance have higher odds of Present Host information in the clinical records compared to patients arriving by other means. (**Table 54**) A test of the full model against a constant only model was statistically significant, indicating that the predictors as a set reliably distinguished between Present and Absent Host information in the clinical documentation ($\chi 2$ (9) = 127.970, $p<.05$). Nagelkerke's R2 of .150 indicated a weak relationship between prediction and grouping. However, overall prediction success was 70%, the model performing better at predicting those cases where information will be Present (90.7%) compared to Absent (19.5%). The Wald criterion demonstrated that Hospital size, patient sex and length of stay did not make a significant contribution, and these variables were not retained in the model. Arrival mode (BIBA) did significantly contribute to the predictive power of the model (Wald $\chi 2$ (4) = 27.660, p<.05). EXP(B) value indicates that when an ambulance record is present in the hospital chart that the odds ratio is 2.4 times as large and therefore the medical record is 2.4 times more likely to contain Host information.

Table 54 Logistic Regression - Host

HOST	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
HospLocalnum(1)	-.403	.141	8.175	1	.004	.668	.507	.881
AgeGrpBroad			42.168	5	.000			
AgeGrpBroad(1)	.899	.187	23.096	1	.000	2.456	1.703	3.544
AgeGrpBroad(2)	1.029	.216	22.620	1	.000	2.798	1.831	4.275
AgeGrpBroad(3)	.790	.254	9.675	1	.002	2.202	1.339	3.622
AgeGrpBroad(4)	.173	.319	.294	1	.587	1.189	.636	2.224
AgeGrpBroad(5)	-.202	.273	.550	1	.458	.817	.479	1.394
Arrival Mode(1)	.865	.165	27.660	1	.000	2.376	1.721	3.280
Mech_logreg			20.076	2	.000			
Mech_logreg(1)	-1.060	.250	18.006	1	.000	.346	.212	.565
Mech_logreg(2)	-.557	.232	5.777	1	.016	.573	.364	.902

(Cox and Snell R Squared = .105; Nagelkerke R Squared = .150)

A second logistic regression model was developed to compare whether patients arriving at hospital by ambulance have higher odds of Present Mechanism information in the clinical records. A test of the full model against a constant only model was statistically significant, indicating that the predictors as a set reliably distinguished between Present and Absent Host information in the clinical documentation ($\chi 2$ (4) = 32.293, p<.05). Nagelkerke's R2 of .151 indicated a weak relationship between prediction and grouping. However, overall Prediction success was 97.9% (0% for Absent and 100% for Present). According to the Wald criterion, only Hospital locality, Hospital sixe and Injury Mechanism group significantly contributed to the model. Arrival mode (BIBA) did not significantly contribute to the predictive power of the model and was not retained. (**Table 55**)

Table 55 Logistic Regression - Mechanism

MECHANISM	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
HospLocalnum(1)	-1.088	.441	6.091	1	.014	.337	.142	.799
HospSizenum(1)	17.441	2690.011	.000	1	.995	3.75E+07	.000	.
Mech_logreg			4.818	2	.090			
Mech_logreg(1)	-16.155	2856.403	.000	1	.995	.000	.000	.
Mech_logreg(2)	-17.788	2856.403	.000	1	.995	.000	.000	.

(Cox and Snell R Squared = .028; Nagelkerke R Squared = .151)

A third logistic regression model was developed for the presence of Object information in the clinical records (**Table 56**). The full model was statistically significant ($\chi 2(10) = 117.163$, $p<.05$), accurately predicting 88.3% of cases (5.2% Absent, 99.2% Present). Nagelkerke's R2 of .188 indicated a weak relationship between prediction and grouping. The Wald criterion demonstrated that length of stay was the only independent variable that did not make a significant contribution to the model. Arrival mode (BIBA) did significantly contribute to the predictive power of the model, with the EXP(B) value indicating that when an ambulance record is present in the hospital chart it is 2.5 times more likely to contain Object information (Wald $\chi 2(10) = 13.752$, $p<.05$):

Table 56 Logistic Regression - Object

OBJECT	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
HospSizenum(1)	.667	.314	4.504	1	.034	1.949	1.052	3.609
Sexnum(1)	-.468	.204	5.285	1	.022	.626	.420	.933
AgeGrpBroad			24.299	5	.000			
AgeGrpBroad(1)	-.233	.300	.603	1	.438	.792	.440	1.427
AgeGrpBroad(2)	-.501	.307	2.654	1	.103	.606	.332	1.107
AgeGrpBroad(3)	-.394	.363	1.179	1	.277	.674	.331	1.373
AgeGrpBroad(4)	-1.157	.404	8.204	1	.004	.314	.142	.694
AgeGrpBroad(5)	-1.529	.333	21.049	1	.000	.217	.113	.417
BIBA(1)	.897	.242	13.752	1	.000	2.452	1.526	3.940
Mech_logreg			8.966	2	.011			
Mech_logreg(1)	-19.491	2918.056	.000	1	.995	.000	.000	.
Mech_logreg(2)	-18.841	2918.056	.000	1	.995	.000	.000	.

(Cox and Snell R Squared = .096; Nagelkerke R Squared = .188)

A final regression model was developed to examine the independent relationship between arrival mode at hospital and the presence of Environment information within the clinical documentation (**Table 57**). The resulting equation was statistically significant ($\chi 2(7) = 349.269$, $p<.05$), retaining Hospital Locality, Age group and Arrival mode (BIBA) as predictors based upon the Wald statistics. Nagelkerke's R2 of .348 indicated a moderate relationship between prediction and grouping. The model accurately predicts 72.6% of cases for the presence or absence of relevant information (91.5% Absent; 56.6% Present). Arrival mode by ambulance had a large impact on the likelihood of present Environment information in the medical record. ($\chi 2$ (1) = 215.303, $p<.05$) Hospital charts with an ambulance record present are 15.0 times more likely to contain Environment information than charts without ambulance documentation.

Table 57 Logistic Regression - Mechanism

ENVIRONMENT	B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I.for EXP(B)	
							Lower	Upper
HospLocalnum(1)	-.436	.142	9.354	1	.002	.647	.489	.855
AgeGrpBroad			15.105	5	.010			
AgeGrpBroad(1)	-.398	.178	5.029	1	.025	.671	.474	.951
AgeGrpBroad(2)	-.514	.202	6.439	1	.011	.598	.402	.890
AgeGrpBroad(3)	-.413	.251	2.718	1	.099	.662	.405	1.081
AgeGrpBroad(4)	-.332	.363	.839	1	.360	.717	.352	1.461
AgeGrpBroad(5)	.522	.334	2.433	1	.119	1.685	.875	3.245
BIBA(1)	2.711	.185	215.303	1	.000	15.039	10.471	21.601

(Cox and Snell R Squared = .260; Nagelkerke R Squared = .348)

6.7.6 Summary of results

Code assignment errors were assessed by comparison of the original code assignment to the audited code. A coding error was determined to have occurred when a change to the audited code assignment resulted in a change of Haddon's element Present/Absent status. Error rates ranged from 2% for Host information for Falls cases to 15% for Environment information, again within Falls codes. Instances of both False Negatives (loss of information between the narrative text and original code assignment) and False Positives (inclusion of false injury information in the original code assignment) were evidenced, with varying proportions across the Haddon's element and key injury types. Notably, the Environment element had high levels of both False Negatives and False Positives amongst code groups.

The impact of code system limitations on information quality was assessed by comparing the presence/absence of Haddon's information in the source documentation to audited code. A loss of information (Type II errors) was evident as a consequence of the process of translating written information from the medical records into the audited ICD-10-AM code. Environment information had the highest levels of Type II errors. In 68% of cases where Environment information was absent from the coded record, it was deemed to have been present in the source documentation. Examining this phenomenon by the key injury groups of Falls and

Transport-related injuries showed higher false negative rates were five times higher amongst Falls codes than Transport-related codes.

Source documentation (clinical records) were examined for the presence of information relating to each Haddon's element to establish the level of documentation sufficiency. Manual review of medical records showed that Environment information was the least available element within the record (52%), with Mechanism information being the best document (98% of cases). Completeness of information within the records did vary by Haddon's element and injury mechanism group.

Crude associations were found between presence of information in the medical record and hospital size and locality, injury mechanism, patient age and gender, the strength of these associations vary across the Haddon's elements. One factor that was associated in the unadjusted analyses with presence of information for all Haddon's elements was Arrival Mode of Brought in By Ambulance.

Further analysis of the association between arrival mode by ambulance and information quality of source documentation was undertaken. One-third of patients (33.6%; n = 389) arrived at hospital by ambulance (BIBA). Ambulance transported cases were skewed towards the older age groups, and had longer lengths of stay in hospital. ($p<.05$). Cases arriving by ambulance were 2.26 times more likely to contain Host information; 3.61 times more likely to have Mechanism information; 1.71 times more likely to have Object information; and 14.43 times more likely to contain Environment information.

Adjusted analyses (multivariable logistic regressions) were conducted to identify the independent contribution of arrival mode by ambulance to the presence of injury information in the medical records. The developed models adjusted for potential confounders, as identified in the earlier analyses of crude associations (hospital size and locality, injury mechanism, patient age and gender). Length of Stay was also included in the model as arrival by ambulance was strongly correlated with this factor. Separate regression models were developed for each Haddon's element.

The regression model for the presence of Host information identified a significant independent contribution of arrival mode by ambulance to the predictive power of the model, once the impact of other independent variables had been accounted for. Cases with an ambulance records were 2.4 times more likely to have present Host information. In this model, Hospital Locality, Patient Age, and Injury Mechanism also each made significant independent contributions to the model (p<05). The final model had an overall prediction success of 70% (19.5% for Absent and 90.7% Present).

Arrival by ambulance was not retained in the model for presence of Mechanism information, however Hospital Locality, Hospital Size and Injury Mechanism did attain the required level of significance ($p<.05$). Overall prediction success of the final model was 97.9% (0% for Absent and 100% Present).

By comparison, arrival mode by ambulance did attain the required level of significance for retention in the regression models developed for both Object and Environment information. These models had overall prediction success levels of 88.3% (5.2% for Absent and 99.2% for Present), and 72.6% (91.5% for Absent and 56.6% for Present), respectively. Arrival mode had the strongest effect size of all predictor variables in each of these models. Cases that arrived at hospital by ambulance were 2.5 times more likely to contain Object information, and 15.0 times more likely to contain Environment information.

6.8 *Discussion*

The production of injury causation data is a multi-step process, from the documentation of textual information within the medical records, as completed by clinicians involved in patient care, to the translation of this information to a coded data form by Clinical Coders using a standardised coding system. A number of points have been identified at which errors or loss of information can occur during this process: these may be associated with the source documentation, the human coders, or the structure of the code system in use. A study by McKenzie, Enraght-Moony and Harding et al. (2008) exploring coders' views as to the most influential aspects on coded external cause of injury data quality, identified documentation insufficiencies as having the greatest impact. This opinion, however, has yet to be validated. The purpose of this study was to perform a detailed examination of clinical records to identify the contribution of each of these factors to the loss of relevant injury information, or the introduction of unsubstantiated details, within the coded dataset.

In summary, the following key error sources were examined in detail:

a) coding errors - inaccuracies introduced as a result of the code assignment as performed by the hospital Clinical Coder;

b) code system limitations - information available within the clinical records but lack of codes in the code system to accurately capture;

c) documentation limitations - code available but lack of documented information to assign a specific code.

Coding Errors: To what extent do code assignment errors contribute to: a) loss of information regarding a Haddon's element in the coded dataset; b) introduction of false information about a Haddon's element in the coded dataset?

To identify the rate of coding errors, and the impact of these on the information conveyed by the coded data, an auditor performed a detailed data extraction and recoding exercise on injury-related clinical records. The presence/absence of each Haddon's element within the original code was compared with that of the Auditor assigned code (proxy gold standard). Where there was a difference between original and audited code, and this resulted in a change as to the presence or absence of a Haddon's element, this was counted as a coding error. Overall error rates were further examined to identify their tangible impact on the accuracy of the coded data, in terms of the resultant loss or introduction of detail.

Overall coder error rates, averaged across all injury mechanisms, ranged between 5% and 8% of codes for each Haddon's element. However, variation was evidenced across each key injury mechanisms, with levels as high as 15% found for Environment information amongst Falls codes. Coder error, therefore, results in a considerable amount of information quality degradation. This reduction in quality resulted in both the introduction of spurious information (false positives) and loss of information (false negatives) from the coded form. Mechanism & Object/Perpetrator elements were particularly affected by the introduction of false information, with approximately a quarter of positives made in error. Transport codes had high false positives for Host (0.50) and Environment (0.19), however it should be noted that both of these findings are affected by the small number of transport codes that were absent for these elements.

Coding errors that result in false positive results may be due to either individual coder decision or the pre-coordinated nature of code system (i.e., forced choice). For example, where documentation states "tripped and fell over" the environment is not present in the narrative, but coder assigns "Fall on same level" (W18.9) which is an environment specified code. This coding choice can be due to poor indexing of the codes in the ICD-10-AM code system and a lack of guidance for the coder; ambiguity of coding rules/inclusion/exclusion criteria and a lack of coder education regarding this specific code block; or, complexity of injury scenarios that leads to misinterpretation errors. Introduction of false information in the dataset misrepresents the influence of particular risk factors or causes of injury and reduces the utility of this data for designing effective prevention strategies.

By contrast the Environment element had a higher level of false negatives (13%), which is associated with a loss of information. Loss of information in the original code compared to the audited code to the coded form may either be due to individual coder choice or as a consequence of code system limitations. The ability to accurately represent narrative information is limited by the range and structure of available codes within the code system. For example, in the case where a patient falls over on a single level due to tripping on a skateboard, the coder has the options of selecting "Fall on same level (tripping)" (W01.1), "Fall involving ice-skates, skis, roller-skates or skateboards (W02.2), or "Other fall on same level" (W18.9). Each choice requires a compromise, losing one element of information in preference for collection of another aspect.

There was a notable lack of agreement between the original code and the audited code for Environment information in Falls cases, with relatively high false positive (0.11) and false negative (0.20) rates. This identifies this code area to be of high priority for development, with a need to further explore the varying causes of the losses to information quality, whether they are due to a lack of guidance in this area, inconsistent documentation, a lack of value seen in this area by coders, or inappropriate code categories within this block.

Code System Limitations: To what extent do insufficiencies within the ICD-10-AM code system contribute to information attrition in the coded dataset (compared to the base information quality level of the source documentation)? Are there key areas where clinical documentation could currently support a more detailed code structure?

As discussed above, there is a potential interaction between coder error and code system limitations, with coder's choice potentially being 'forced' due ambiguities or insufficiencies in the code system. To partial out the impact of code system limitation from coder error a comparison was made between the presence of each of the Haddon's element in the audited code (proxy gold standard) versus the source documentation. The code area with the greatest loss of information due to code system constraints was Environment (68% false negatives) across all injuries. This information attrition far exceeds the loss that was associated with coder error (13%). Notably, the only mechanism code block that wasn't affected was that of Transport-related injuries. Other Haddon's element with high levels of information loss due to code system constraints was Host information (57% false negatives), due in particular to Fall and Other mechanism code blocks.

Transport codes, which are the most detailed section of the code system have the lowest false negatives of all mechanism groups, and is the only mechanism that doesn't have high false negatives for Host and Environment elements. The low rates of information loss for Transport-related events, when transferring information from narrative to coded form indicates that the comprehensive nature of this section of the code system enables capture of the majority of the injury information, at some level. Notably though, Transport codes do have a high level of false positives for both Host and Environment. This suggests that the trade-off of this highly complex and detailed section of the code system, with associated low loss of information, is also responsible for the introduction of unsubstantiated elements due to the intertwined nature of the codes (e.g. Motorcycle rider injured in collision with two- or three-wheeled motor vehicle, while boarding or alighting, motor-scooter, moped or motorised bicycle (V22.3)). A similar effect of the more detailed code structure is evidenced for Mechanism & Object/Perpetrator information, with likewise higher false positives than negatives rates. This suggests that again that given the pre-coordinated structure of ICD-10-AM codes, more detailed code options whilst reducing loss of information also forces introduction of additional unsubstantiated information. Of particular note are is the Object element for Falls codes, where all instances of 'present' Object information in the audited code were found to be false positives when evaluated against the presence of this information in the source documentation.

Examination of the entire code set indicates that Falls, Other Injuries and Environment code elements would most benefit from more detailed code structure. Whilst the high rate of false positives amongst the highly detailed transport code section indicates that the complex, pre-coordinated nature of ICD-10-AM needs further consideration.

3. Documentation Sufficiency: What is the level of documentation sufficiency (conceptualised as coverage of Haddon's Matrix elements) to support detailed coding of external cause of injury factors? Are there particular code blocks, injury mechanisms, or Haddon's elements for which documentation is particularly lacking pertinent information required to inform Haddon's Matrix?

Medical records within the hospital chart were reviewed in detail to benchmark the available levels of information relating to each of the Haddon's elements. Environment information was poorest with only 52% of all records containing relevant details. Whilst documentation quality was high for some mechanism and elements (e.g. Mechanism and Object for transport = 100%), and lacking for others (Environment information present in only 52% of all records). Lack of information within the source documentation is a limiting factor in terms of development of external cause of injury coding, as any code system developments will not be realised until information is available within the records to support the assignment of detailed codes. This highlights the paramount importance of investing in the development of injury documentation, in particular with regards to Environment information.

Presence of information regarding an injury is likely to be associated with patient and system factors, such as hospital size and locality, injury mechanism, patient age and length of stay in hospital, and arrival mode to hospital. Crude analyses measuring the association between these factors and documentation completeness for each of the Haddon's elements revealed a number of significant associations. However, the only factor that was consistently significantly associated with a higher level of present information, across all Haddon's elements, was arrival at hospital by ambulance (BIBA). Cases arriving by ambulance were between 1.7 times (Object) to 14.4 times (Environment) more likely to contain relevant injury information in their medical record than patient that arrived by other means. This finding supports the coder opinions in the survey conducted by McKenzie, Enraght-Moony, Harding, Walker, Waller, & Chen, (2008) regarding the utility of ambulance records for injury information. The arrival of a patient at hospital by ambulance, and therefore the presence of an ambulance record in the medical chart, is significantly associated with more information in the entire medical record. However, a number of factors, such as injury mechanism and hospital size were also variously associated with presence of the one or more of the Haddon's elements. The relationship between ambulance arrival status and record quality may be confounded by patient and system factors that are also related to ambulance use. For this reason, adjusted analyses were conducted to measure the independent impact of arrival by ambulance at hospital, and thereby presence of an ambulance record in the hospital chart, on the presence of injury information.

4. Ambulance Records: What is the capacity of prehospital records to provide relevant injury causation details to enhance in-hospital data collections? To what extent does the presence of an ambulance record in the hospital chart contribute to the information quality of the overall source documentation for external cause of injury?

Crude analyses of the relationship between mode of arrival and the information quality of the hospital chart showed ambulance records to have a positive impact on the presence of Haddon's information in the medical records. However, unadjusted analyses (chi square) showed ambulance patients to differ significantly from other patients on a number of factors (gender, age, LOS, mechanism of injury). Logistic regression models were built for each of the Haddon's elements, accounting for these confounding factors in the adjusted models. Interaction terms were not entered in to the model as there was no a priori reason for inclusion.

Arrival mode was retained in three models (Host, Object/Perpetrator, Environment), indicating that when other factors are accounted for arrival mode still has a significant independent effect on the quality of the outcome measure of medical record information quality. In the final adjusted models, patients with ambulance records were approximately 2.5 times more likely to have present Host and Object/Perpetrator information, and 15 times more likely to have present Environment information. Arrival mode had the second largest effect size of all factors for the Host regression analysis, and the largest for the Object/Perpetrator and Environment models.

No single factor was retained in all four regression models; the maximum number of models for any factor being retained was three. The only model that arrival mode was not retained in was the Haddon's element of Mechanism. Examining the proportion of cases with present Mechanism by arrival mode reveals a potential ceiling effect, with 98% of all records containing Mechanism information (99% present for ambulance arrivals; 97% present for non-ambulance arrivals).

The developed models had low R^2 values indicating a weak relationship between the predictor variables and the outcome. However, the logistic regression models proved better at predicting the presence of information within a record, than absence (90-100% present; 0-19.5% absent), for all elements except Environment (91.5% absent; 56.6% present). The stronger positive predictive power of the Environment model is likely due to the large effect size for arrival mode ((EXP)B=15.0).

6.8.1 Limitations

Despite there being guidelines and rules to direct code assignment, given the wide and varied scenarios and facts that surround injury events, coding is still to some extent a subjective exercise. Identification of errors due to the coder variability was performed by comparing the original code assigned within the QHAPDC data to that of the expert auditor. As no definitive measure of coding accuracy is available, an expert auditor assigned code was used as a proxy gold standard to enable benchmarking of introduced error due to individual coder variance. It is, however, possible that some of the coding error measured may have been introduced on the part of the Auditor (i.e. not original coder). The potential introduction of error on the part of the experienced auditor also serves to highlight the ambiguities and potential frailties of the system in producing standardised and reliable coded representations for injury events.

The auditor, who was substantively employed as an educator in clinical coding, was selected on the basis of their long experience in, and proficiency with coding, to ensure the quality of the review conducted. A single expert coder was used as the reference standard to reduce the number of error sources in the coding processes being compared. Use of multiple coding auditors would have the potential to introduce additional errors, with need for comparison with a referent category still required (i.e. expert coder). It was decided on the basis of resourcing constraints that it was not necessary to employ multiple coders to undertake re-coding exercises for cross comparison, as a appropriate benchmark could be established using a single expert coder for comparison.

The ICD-10-AM code system for external cause of injury is a complex tool, the characteristics of which place restrictions on coders in terms of both permissible and available code options. Therefore, some 'coder errors' may be more of a reflection of restrictions of the ICD code system (i.e. "forced errors" due to code constraints), rather than individual coder error resulting in appropriate code selection. Coder error was assessed by comparing the original code within QHAPDC dataset with an audited code. Any difference in code assignment that substantively affected the 'presence' or 'absence' of a Haddon's element within the resulting code was identified as a coding error. It is likely where there are fewer, more sporadic errors within a code block that these are due to random coder error. Where a high level, or cluster, of coder errors was identified within a code block this is likely to be symptomatic of the impact of systematic issues, such as code system structure and lack of coding guidance, on the 'forcing' of coding errors. Across the entire code system, errors attributed to the coder were comparatively low (averaging between 5 & 8% for each Haddon's element across all mechanisms). To further explore this issue the impact of code system constraints on code assignment was also explored separately.

For some cells within the tables examining error rates, high false positive and negative rates were evidenced due to low numbers of cases. This was due to either small case volumes within these Mechanism and Haddon's element combinations, or lack of variation in coding patterns (i.e. all or the vast majority of codes are clustered around the same value). Mention of notable exceptions has been made in the reporting of Results.

A sample size calculation was not able to be performed prior to data collection for this study. Firstly, sample size was constrained by a number of factors logistical considerations such as cost and feasibility of timeframes for data collection. Secondly, multiple comparisons were planned with no similar studies available to provide any estimation as the expected magnitude of effect for each comparison. The effect sizes, of both crude and adjusted analyses, indicate post-hoc that the sample had sufficient power to address the key research questions regarding the sufficiency and independent contribution to quality of the clinical documentation sources.

As discussed in earlier sections of this thesis, some information regarding Host factors may be collected in other sections of the medical record, as opposed to within the external cause of injury codes (eg. demographic sections). However, this information does not get systematically incorporated into the external cause collection, and therefore is not readily amenable to integration for analysis. It is therefore likely that in the majority of cases this information is either not available to, or reliably and effectively utilised by researchers in their studies. The purpose of this study was specifically to evaluate the information quality of ICD-10-AM external cause of injury codes, as a dedicated collection of cause of injury information. It is for this reason that information from field outside of the ICD-10-AM cause of injury codes was not incorporated into the assessment for this study.

Similarly, information regarding the Place of Occurrence and Activity at Time of Injury is recorded in separate codes to the main external cause of injury code. External cause of injury codes can be assigned with any combination of Place of Occurrence and Activity codes. As noted in Study One, the information provided by these codes is very generic (e.g. provides broad geographic location information such as 'Private Residence', as opposed to specific environmental details). Linking associated external cause of injury, place of occurrence and activity codes within the QHAPDC dataset is problematic as the order of codes is not always retained during the processing of this dataset. Tying these codes to each other for the purpose of analysis by a researcher is equally as difficult, which is a noted limitation of the current ICD-10-AM code system. It was not feasible, with in excess of 2,500 external cause of injury codes, to evaluate each of this in combination with every Place of Occurrence and Activity code. For this reason Place of Occurrence and Activity codes were not considered in this study. This may have led to an underestimation of the presence of pertinent injury information (such as Environment information contained within the Place of Occurrence codes), however it does provide an accurate profile of the value of the most consistently utilised portion of the code system, the external cause of injury codes.

Review of ICD codes and medical documentation for the presence of Haddon's elements was performed on the straightforward basis of a dichotomous "Present/Absent" outcome. This enabled the counting of only a single detail for each Haddon's element, and was therefore unable to quantify where multiple pieces of information regarding an element are present. Additionally, as discussed in Study One of this thesis, no evaluation was performed as to the nature or utility of this particular detail, as this would require content specific expert knowledge for each specific injury mechanism. The purpose of this study was to develop and evaluate a framework for measuring and characterising the information quality of the ICD-10-AM external cause of injury codes in a more systematic manner than the current 'defined/undefined' matrix of data quality. Further qualitative evaluation of the relative content specific value of each code is an immense piece of work far beyond the scope of this dissertation. To extend beyond this initial appraisal will require detailed dissection of the entire ICD-10-AM external cause of injury chapter into theoretically homogenous subsections. Engagement of content specific experts to provide evaluation of the relative importance of specific injury details to each subcomponent will be required to provide assessment of the information quality of the these codes in their specific contexts of use.

CHAPTER 7. DISCUSSION

7.1 *Introduction*

Injuries represent a major direct and indirect cost to the Australian health-care system. Injury researchers rely on accurate data concerning the circumstances surrounding injury events to develop effective prevention strategies. A potentially invaluable resource for researchers is hospital morbidity data, a population-based injury dataset. To produce hospital morbidity data, information documented in hospital records is translated into standardised codes suitable for statistical aggregation and analysis. ICD-10, a clinical coding system published by the World Health Organisation, is the most commonly used medical classification system worldwide. In Australia, Chapter XX (External causes of morbidity and mortality) of the ICD-10-AM (Australian modification of ICD-10) is used to collect and store external cause of injury information in hospital morbidity data.

The central role of data in informing injury prevention activities was explored, and the need for further development of available injury information highlighted. It was established that there is a dearth of available evidence regarding the utility or quality of the ICD-10-AM external cause of injury codes for their primary purpose – injury research. A pivotal aspect to enhancing the quality of coded hospital-based injury data is rigorous evaluation and evidence-based development the ICD-10-AM classification system. To this purpose a novel concept for the definition and quantification of injury data quality was introduced. This approach, grounded in a key injury research theoretical framework, Haddon's Matrix, extended the concept of quality beyond a traditional simplistic data completeness measure to one that evaluates the 'fit-for-purpose', or appropriateness, of the resultant information for the purpose of injury research.

Improvement of injury data quality extends beyond development of the ICD-10-AM code system in isolation. The quality of the data produced using the code system is dependent upon a number of factors such as the completeness of available source documentation and coder consistency. Based upon the expert opinion of clinical coders surveyed across Australia (McKenzie, Enraght-Moony, Harding, Walker, Waller, & Chen, 2008), with regards to factors that will greatest impact on hospital morbidity data quality for injury, source documentation completeness was identified as the highest priority. Additionally, ambulance records were identified as being the most valuable data source for injury information. Consequently, specific focus was placed on examining ambulance report forms for external cause of injury information, and evaluating the capacity for this documentation source to be more fully utilised to increase the precision of the in-hospital coding process for cases transported by ambulance.

Based upon the identified gaps in the relevant literature, this research was conducted with the following main aims:

1. To trial an epidemiological framework to assess the ‘fit-for-purpose’ of ICD-10-AM external cause of injury codes, and coded data, for injury research;
2. To evaluate the ‘fit-for-purpose’ of ICD-10-AM coded external cause of injury information within the Queensland Hospital Admitted Patients Data Collection;
3. To identify causes of poor information quality within the Queensland Hospital Admitted Patients Data Collection external cause of injury data;
4. To measure the completeness of injury information within medical records and evaluate the potential to enhance current external cause of injury data through improved utilisation of ambulance documentation.

It was expected that achieving these aims would provide a systematic measure of injury information quality, grounded in injury prevention theory, and provide an evidence-base for the enhancement of external cause of injury data collections.

The following research questions were developed to inform these aims and guide the program of research:

RQ1 What percentage of codes are 'Undefined' (poor data completeness) within the ICD-10-AM external cause of injury code set? Does the proportion of 'Undefined' codes vary by injury mechanism and intent?

RQ2 What percentage of codes contains information that relates to each of the Haddon's injury elements (Host, Agent, Environment)? Does the percentage differ by injury mechanism and intent?

RQ3 To what degree does the traditional 'Defined/Undefined' view of quality over- or under-estimate ICD-10-AM code quality compared to the Haddon's Matrix model?

RQ4 Does the Haddon's Matrix conceptualisation provide a more comprehensive coverage and a more specific measure of code quality than the 'traditional' Defined/Undefined categorisation? Is there any difference by injury mechanism and intent?

RQ5 Can high priority code blocks for quality improvement be identified, due to a low prevalence of Haddon's elements (Host, Agent, Environment information)?

RQ6 What is the 'information quality' of the Queensland hospital morbidity dataset for injury research? Does the information quality vary by injury mechanism and intent?

RQ7 What are the relative utilisation rates within the hospital morbidity dataset of 'high' and 'low' information quality codes, identified in Study 1? Can high priority code blocks for quality improvement be identified due to either a high prevalence or overutilisation of codes with 'Absent' Haddon's elements (Host, Agent, Environment information)

RQ8 Coding Errors: To what extent do code assignment errors contribute to: loss of information regarding a Haddon's element in the coded dataset; and, introduction of false information about a Haddon's element in the coded dataset?

RQ9 Code System Limitations: To what extent do insufficiencies within the ICD-10-AM code system contribute to information attrition in the coded dataset (compared to the base information quality level of the source documentation)? Are there key areas where clinical documentation could currently support a more detailed code structure?

RQ10 Documentation Sufficiency: What is the level of documentation sufficiency (conceptualised as coverage of Haddon's matrix Matrix elements), to support detailed coding of external cause of injury factors? Are there particular code blocks, injury mechanisms, or Haddon's elements for which documentation is particularly lacking pertinent information required to inform Haddon's Matrix? Are there key areas where clinical documentation could currently support a more detailed code structure?

RQ11 Ambulance Records: What is capacity of prehospital records to provide relevant injury causation details to enhance in-hospital data collections? To what extent does the presence of an ambulance record in the hospital chart contribute to the information quality of the overall source documentation for external cause of injury?

Three complementary studies were designed to answer the research question and thereby achieve the overall research aims. The relationship of each of the studies to the central themes of the research is presented below.

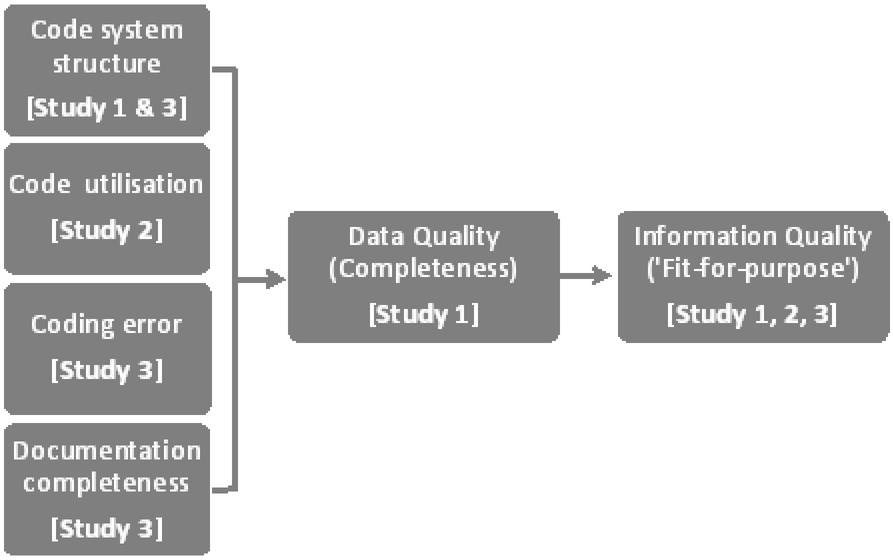

Figure 14 Thesis structure diagram with core quality concepts

Study One involved the categorisation and analysis of the ~2200 ICD-10-AM external cause of injury codes, using the proposed Haddon's matrix framework. This main aims of this study were to evaluate the underlying structure and data completeness of the ICD-10-AM code system, addressing research questions one to five. Mapping of the Haddon's Framework categorisations of the ICD-10-AM external cause of injury codes (as developed for the first study) to codes assigned within the Queensland Hospital morbidity data was performed in Study Two. This study was performed to examine the utilisation of ICD-10-AM external cause of injury codes in 'real life' application, and to measure the 'fit-for-purpose' of the resulting dataset. A quantitative descriptive analysis of the resultant dataset was performed to address research questions six and seven. Finally, Study Three involved a detailed on-site medical record review conducted by an expert clinical coder to measure the independent impacts of coding error and documentation sufficiency on the information quality of hospital morbidity data, as detailed in research questions eight to eleven.

7.2 *Review of Findings*

The findings relating to each of the three studies within this thesis have been described in detail earlier in the dissertation. Presented following is an integrated discussion of the key findings and implications from across the three studies, as they collectively relate to and build on the core "quality concepts" within this program of research.

7.2.1 Data vs Information Quality

The fundamental issue of investigation in this program of research is the quality of coded injury data for the purpose of injury research, and methods by which this may be improved. Whilst there is a distinct lack of published evidence evaluating ICD-10-AM external cause of injury codes, the small body of work available uses a rudimentary operational definition of data quality. Historically, studies of the ICD code system have conceptualised code quality by the presence of 'Other specified' or 'Unspecified' in the text descriptor, or a terminal code digit of .8 or .9. If no explicit 'undefined' aspect is identified, the code is defaulted to a 'Defined' status. Based upon this rudimentary categorisation, examination of the underlying ICD-10-AM code system, as performed in Study One of this thesis, found that overall 92% of codes within ICD-10-AM Chapter XX were classified as 'Defined'. This would indicate that only 8% of the total 2,240 codes examined were classified as being of being poor quality using this measure. This finding is in contrast to the criticisms in the literature of the lack of precision, or detail, of ICD codes for injury research (refer Section 2.5.1.3), and indicates that this is an insensitive measure of quality that does not reflect the users' needs of the data.

The defined/undefined categorisation provides only a single crude measure of data quality that takes an "all or nothing" approach. The measure is based not upon the scope of detail provided, but on the criterion that any stated data must be of a specific nature. The total absence or omission of certain details is not detected by this method. Additionally, this measure does not account for multiple elements of information being contained within pre-coordinated ICD codes (i.e., a single code can contain some or all of intent, mechanism, host, agent, and environment element of injury information). Evaluating codes in this manner lacks the precision required to accurately discern between a code that contains an aspect of 'nondefined' data in combination with multiple other specific aspects (e.g. V24.9 Unspecified motorcycle rider injured in collision with heavy transport vehicle or bus in traffic accident), and a code with sparse but defined information (e,g, W05 Fall involving wheelchair). Under this conventional means of assessing code quality, the sparse, but technically 'fully defined' code would be evaluated to be of higher quality than the code that contains multiple elements of pertinent injury information in accompaniment with an 'undefined' code descriptor. Thus, whilst this method of defining data quality leads to a largely positive assessment of overall data completeness, the measure lacks the sophistication required to suitably reflect the complex code structure of ICD-10-AM codes.

Data, as with the example of ICD-10-AM codes, are merely a raw sequence of symbols or representations; it is not until the data are assembled, contextualised and interpreted that they become information (NHS, 2004). The assessment of data completeness by the presence of "Other or Unspecified" information provides a measure of ICD-10-AM data quality. Data quality does not, however, measure the utility of these data for the end purpose to which they are being applied; this is the realm of information quality. Information is data that has been interpreted, given context, or to which commentary has been added by a user for a purpose, giving it 'value' (NHS, 2004). Measurement of information quality concerns the application of data to end-user needs; for ICD-10-AM external cause of injury codes this is injury research. Accordingly, this thesis proposed a novel framework, based upon foundational injury prevention theory, to systematically evaluate the information quality of ICD-10-AM external cause of injury codes.

Studies One and Two of this thesis measured and compared the performance of the 'defined/undefined' and Haddon's matrix measures of quality for ICD-10-AM external cause of injury codes. The following research questions were addressed:

RQ3 To what degree does the traditional 'Defined/Undefined' view of quality over- or under-estimate ICD-10-AM code quality compared to the Haddon's Matrix model?

RQ4 Does the Haddon's Matrix conceptualisation provide a more comprehensive coverage and a more specific measure of code quality than the 'traditional' Defined/Undefined categorisation? Is there any difference by injury mechanism and intent?

RQ6 What is the 'information quality' of the Queensland hospital morbidity dataset for injury research? Does the information quality vary by injury mechanism and intent?

An evaluation of the proposed information quality measure, based on Haddon's Matrix framework, was conducted in Study 1. This study dissected the underlying code system to benchmark the quality of ICD-10-AM codes distinct from other influences. Each code was examined to identify the presence or absence of key injury information contained within the code descriptor. The elements were based upon Haddon's Matrix framework of Host, Energy, Vehicle/Object, Vector/Perpetrator, and Environment elements, which is used to analyse injuries to identify causes and risks, and develop prevention strategies. The defined/undefined and Haddon's Matrix categorisations were compared for each ICD-10-AM code.

Results established the utility of the Haddon's Matrix framework for defining and measuring information quality of injury data. The novel Haddon's Matrix conceptualisation, when contrasted with the established measure of data quality based on a crude data completeness measure (defined/undefined code status), demonstrated equivalent completeness of coverage (proxy sensitivity measure) to the current data completeness measure. This indicates high levels of agreement between the Haddon's element categorisation (i.e., Present/Absent) and the 'traditional' Defined/Undefined in detecting true positive cases (i.e., where Haddon's element is recorded as 'Present', traditional method is recorded as 'Defined'). Across the Haddon's elements, for many injury mechanisms, the defined/undefined and Haddon's categorisations agreed as to the "defined" or "present" quality of codes in the region of 80% to 100%.

However, the Haddon's Matrix conceptualisation of information quality demonstrated far superior levels of specificity. The defined/undefined measure was accompanied by high levels of false positives, where codes that were absent of relevant injury information as determined using Haddon's framework, were deemed "defined". A categorisation system can maximise sensitivity (or completeness of coverage), at the cost of specificity, by indiscriminately assigning all cases to the positive category. However, this does not mean that the category assignment is accurate, but merely comprehensive. This leads to a high rate of false positives across the majority of mechanism blocks, when the Haddon's Matrix evaluation framework is use as a comparator. Defined/undefined measure specificity ranged between 0% and 15% for all elements with the exception of All Transport - Vehicle/Object (43%). Across all codes, this method overestimates data completeness for in excess of 80% of codes. The lack of specificity is due to the defined/undefined method providing only a single global measure of data completeness, which limits the capacity to accurately characterise the nature of hierarchical, pre-coordinated ICD-10-AM codes.

Study One provided a benchmark of the quality of the underlying code system. This is of importance as it constrains the potential quality of the datasets to which it is applied. The presence of Haddon's elements varied across the injury mechanism blocks, with few consistent patterns. The ICD-10-AM code structure was demonstrated to have the theoretical capacity to systematically collect information regarding Host, Agent and Environment aspects of an injury. However, completeness of coverage for Haddon's elements is inconsistent across code blocks, indicating need for further development work within the code blocks. The most marked area in need of improvement is the Environment element, where ICD 10-AM codes showed low levels of available information.

Study Two extended the evaluation of the information quality of ICD-10-AM external cause of injury codes beyond that of the underlying code system, to that of the codes in application. Codes will be applied to datasets in different proportions to their distribution within the ICD-10-AM code system, dependent upon the frequency of injury events, coding practices, and the availability of information within the hospital records to mandate the appropriate code assignments. Analysis of a statewide hospital morbidity dataset (QHAPDC) was undertaken to examine these patterns and identify how base code system quality translates to coded quality for a population based dataset.

Frequency analyses displayed the incidence of poor information quality codes for specific injury groups within the QHAPDC data, with a large number of individual 'poor quality' code categories identified. Coverage of Haddon's elements within the coded dataset is inconsistent across injury groups. Host and Environment elements had the poorest coverage across all injury types (31% and 30%, respectively). Notably, despite the Unspecified, Other Specified nec, and Other Specified Classifiable residual mechanism categories being described by traditional data quality measures and being 'Undefined' codes, some code categories contained relatively high levels of pertinent injury information (e.g., 65% of Other Specified nec codes contained relevant Vector/Perpetrator information). Thus, whilst a certain aspect/s of a code may be lacking detail, the code may still present information regarding other aspects of the injury causation which is of use to injury researchers. This demonstrates the utility, when examining injury data quality, of adopting a less rudimentary measure by dissecting the coded information into relevant information subcomponents aligned with injury prevention theory.

Use of the Haddon's matrix, founded in injury prevention theory, progressed the assessment of quality beyond whether a specific code was defined, to whether the code contains information that is of use to injury research. Comparison of the information quality of the ICD-10-AM external cause code system to that of the codes as applied to a hospital morbidity data system shows that whilst a number of quality issues have been identified with the underlying codes, these frailties are exacerbated in their application to real injury cases by the high proportion of poor quality code assignment. The predominance of poor information quality codes within the resultant dataset compromises the utility of this data to its end purpose of injury research.

7.2.1.1 **Factors impacting quality**

There are a number of sources for poor information quality, such as errors in systems design, the way the information is processed or the way it is interpreted (NHS, 2004). Studies One to Three each assessed, using the Haddon's Matrix framework, the impact of each of these factors on the information quality of the resulting data collection.

7.2.1.2 **Code utilisation**

The availability of codes within a classification system doesn't necessarily equate to the application of those codes. In the coding process, code selection is dependent upon the nature and extent of underlying information in the medical records, the appropriateness of the codes within the code system, and coding guidelines and rules.

Study Two examined the relationship between code availability and utilisation in the hospital morbidity dataset.

RQ7 What are the relative utilisation rates within the hospital morbidity dataset of 'high' and 'low' information quality codes, identified in Study 1? Can high priority code blocks for quality improvement be identified due to either a high prevalence or overutilisation of codes with 'Absent' Haddon's elements (Host, Agent, Environment information)

Study 2 evaluated the 'fit-for-purpose' of ICD-10-AM external cause of injury codes in the context of a state-wide hospital morbidity dataset. The proportional utilisation of high and low quality codes in the morbidity dataset was compared to the underlying distribution with the ICD-10-AM code set to identify priority areas for code system development. This determination was based upon either a high prevalence of poor information quality (Haddon's 'Absent') codes within the ICD-10-AM base code structure, or overutilisation of poor quality (Haddon's 'Absent') codes with the hospital morbidity dataset.(i.e., overrepresentation within the hospital morbidity dataset compared to the ICD-10-AM base code system).

Across all injury mechanisms and Haddon's elements, codes with present Haddon's information were underrepresented in the coded QHAPDC dataset by comparison to the ICD code system. This indicates that poorer quality codes are being assigned in preference to higher quality codes.

In the underlying code system, Environment had lowest coverage, with only 68% of all codes (i.e., all injury mechanisms) containing any information regarding the physical environment in which the injury occurred. By comparison, within the coded QHAPDC dataset only 30% of assigned codes had Environment information present.

Similarly, Host information was present in 82% of all codes within ICD-10-AM, but only 31% of codes within QHAPDC contained Host elements.

Only two code groups in which codes with Present Haddon's elements were used at a higher frequency in the coded data than in the underlying code system: Other Specified Classifiable codes for Vehicle/Object information (utilisation rate = 1.7); and notably, Falls codes for Environment information (utilisation rate = 1.2). Despite the higher utilisation rate of codes with present Environment information for Falls injuries, these codes still only represented 52% of assigned codes.

Within the QHAPDC dataset, numerous priority areas for data quality development were identified, with a lack of consistency evidenced across code blocks. Notably, the Transport section of the ICD-10-AM code system which is the most detailed of all mechanism groups, accounting for three-quarters of the entire code set, had a high rate of overrepresented poor quality code usage. Comparatively, the Falls code section with ICD-10-AM contains relatively sparse options (2% of code set), yet codes assigned in QHAPDC were generally of high information quality. The comparison of quality code utilisation rates between Transport and Falls code blocks highlights that the number of available codes is not necessarily related to coded data quality.

Code assignment within a dataset can be due to either code structure issues, availability of supporting information to inform code assignment, . Study 3 applied the Haddon's evaluation framework developed in Study 1 to a medical record review methodology to evaluate the contribution of coder error (i.e., error is code selection), documentation deficiencies, and code system deficiencies to the information quality of ICD-10-AM coded hospital morbidity data for injury prevention research.

7.2.1.2.1 Coder error

Study Three evaluated the impact of human error, or coding error, on the reduction of information quality in hospital morbidity data for external cause of injury.

RQ8 Coding Errors: To what extent do code assignment errors contribute to: loss of information regarding a Haddon's element in the coded dataset; and, introduction of false information about a Haddon's element in the coded dataset?

Code assignment errors were assessed by comparison of the original code assignment to the audited code. A coding error was determined to have occurred when a change to the audited code assignment resulted in a change of Haddon's element Present/Absent status. Error rates ranged from 2% (Falls Host information) to 15% (Falls Environment information. Instances of both False Negatives (loss of information between the narrative text and original code assignment) and False Positives (inclusion of false injury information in the original code assignment) were evidenced, with varying proportions across the Haddon's element and key injury types. Thus, coder error results in a considerable amount of information quality degradation.

Mechanism & Object/Perpetrator elements were particularly affected by the introduction of false information, with approximately a quarter of positives made in error. Introduction of false information in the dataset misrepresents the influence of particular risk factors or causes of injury and reduces the utility of this data for designing effective prevention strategies. By contrast the Environment element had the highest level of false negatives (13%), which is associated with a loss of information. Loss of information in the original code compared to the audited code to the coded form may either be due to individual coder choice or as a consequence of code system limitations. Notably, the Environment element had high levels of both False Negatives and False Positives amongst code groups.

The structure and range of codes within a code system constrain the capacity to accurately translate unconstrained narrative information, contained within a medical record, into standardised data elements amenable for statistical analysis. Selection of the most appropriate code choice to represent cause of injury information can involve compromise. Given the pre-coordinated structure of ICD10-AM external cause of injury codes, selection of a single code to collect a pertinent aspect of injury information can result in the consequential loss or gain of another aspect of information. Such a choice can result from forced choices due to code system structure, or individual coder choice within the context of an ambiguous and deficient code system. For this reason, the impact of code system structure on code assignment was examined independently within this program of research.

7.2.1.2.2 Code system structure

The ability to fully describe the information contained within clinical records is constrained by the structure of the code system, and the available codes. Study Three provided more detailed analysis of the specific impact of code structure on resulting information quality through a detailed medical record review methodology. The coding process was examined to identify the loss of information from the underlying document injury details, or generation of false details, as a result of constraints within the code system (RQ9).

RQ2 What percentage of codes contains information that relates to each of the Haddon’s injury elements (Host, Agent, Environment)? Does the percentage differ by injury mechanism and intent?

RQ9 Code System Limitations: To what extent do insufficiencies within the ICD-10-AM code system contribute to information attrition in the coded dataset (compared to the base information quality level of the source documentation)? Are there key areas where clinical documentation could currently support a more detailed code structure?

Study One established the feasibility of deconstructing the structured ICD-10-AM external cause codes into constituent Haddon's elements. Once the ICD-10-AM code descriptors were parsed into their component terms, it was evident that there is large variability in the structure and content of codes by mechanism, intent, and Haddon's injury element. High information quality was found across the code system for the elements of Agent and Host. However, many of these codes are self-definitional as often the intent or mechanism description contains the host or agent information (e.g., Assault by bodily force, person unknown to the victim; Assault = was victim of unlawful act [host information]).

In terms of injury mechanism groups, Transport codes within ICD-10-AM demonstrated the highest proportions of 'Present' items across all Haddon's elements. This is appropriate given that the Transport section of the code system is the most highly developed, containing 70% of the entire ICD-10-AM Chapter XX code set. Transport-related research has historically been a high profile area of injury research, with the development of Haddon's Matrix originating in this field. The Transport section of the code system is complex, containing multiple injury aspects pre-coordinated into the single code. However, the underlying code quality was not found to translate to the coded hospital morbidity data in Study Two. When the Transport codes were applied to injury cases, poorer quality codes were overrepresented within the final dataset. By comparison, the Falls code section with ICD-10-AM contains relatively sparse options (2% of code set) with simpler code structures and lower coverage of the Haddon's elements compared to the Transport section. Yet, Study Two results found that the codes assigned in QHAPDC from within the Falls code block were generally of high information quality. It is likely that the multifaceted nature of the Transport codes precludes the practical application of these codes to injury cases. The capacity to assign a detailed code can be affected by either insufficient information being available within clinical documentation, or an inability to substantiate all circumstances forcing deferral to less detailed codes.

In Study Three, the impact of code system limitations on information quality was assessed in further detail by comparing the presence/absence of Haddon's information in the source clinical documentation to an audited code. Transport codes had the lowest false negatives of all mechanism groups, and were the only mechanism that didn't have high false negatives for Host and Environment elements. The low rates of information loss for Transport-related events, when transferring information from narrative to coded form indicates that the comprehensive nature of this section of the code system enables capture of the majority of the injury information, at some level. In the context of the findings of Study Two, the low false negative rates indicates that the overrepresentation of poor quality codes in QHAPDC are due not to insufficiencies of the code system but rather a lack of available information to support more detailed code assignment. The impact of documentation sufficiency on the information quality of hospital morbidity data was also specifically investigated, and discussion is provided in the following section (Section 7.2.1.3).

Notably, whilst Transport codes had the lowest rates of information loss due to code system structure, they also displayed high levels of false positives for Host and Environment. The trade-off for the highly complex and detailed section of the code system, with associated low loss of information, is the introduction of unsubstantiated elements due to the intertwined nature of the codes (e.g. Motorcycle rider injured in collision with two- or three-wheeled motor vehicle, while boarding or alighting, motor-scooter, moped or motorised bicycle (V22.3)). A similar effect of the more detailed code structure is evidenced for Mechanism and Object/Perpetrator information, with likewise higher false positive than negative rates. This suggests again, that whilst detailed pre-coordinated ICD-10-AM codes reduce loss of information, they concurrently force introduction of additional unsubstantiated information.

In Study Three, Environment information had the highest levels of information attrition in the process of translation from written text to audited code. In 68% of cases where Environment information was absent from the assigned code, it was deemed to have been available in the source documentation. This indicates that the current code system systematically lacks Environment aspects within the current codes. Similarly, examination of false negatives across the entire code set indicated that Falls, Other Injuries and Environment code elements would most benefit from more detailed code structure. Notably, false negative rates, or loss of information, were five times higher amongst Falls codes than Transport-related codes. Use of higher information quality Falls codes in QHAPDC, along with high false negative rates in Study 3 indicates that a more detailed codes structure in this section of the classification would be supported.

As discussed above, there is a potential interaction between coder error and code system limitations, with coder's choice potentially being 'forced' due ambiguities or insufficiencies in the code system. Environment information was associated with the highest level of coder error (13%), and also with the highest level of false negatives due to code system constraints (68% false negatives) across all injuries. Likewise, higher levels of error due to code system structure than coding error were evidenced across the code set. These findings prioritise addressing of code system structure, as this is likely to have a larger impact on information quality. Given the association between code system sufficiency and consistency of coding decisions, improvements to the classification system will consequently reduce coder errors.

In combination, the findings from the three studies highlight the impact of code structure on the nature and quality of assigned codes. In structuring external cause of injury codes it is vital to strike a balance between having sufficient code options to capture all relevant details, and having an overly complex and unwieldy structure that forces either inclusion of false information or default to low quality code assignment. False negatives amongst code categories such as Falls, and for Environment information suggest the need for more comprehensive code options in these areas. Whilst the high rate of false positives amongst the highly detailed transport code section indicates that the complex, pre-coordinated nature of this section of the ICD-10-AM needs further consideration.

7.2.1.2.3 Documentation Completeness

The final factor impacting upon information quality that was expressly investigated was the impact of information availability within the source documentation on code assignment and resultant coded information quality. Based upon literature, the quality of ambulance records for external cause of injury information was specifically measured. These aspects were evaluated in Study 3 with the following research questions:

RQ10 Documentation Sufficiency: What is the level of documentation sufficiency (conceptualised as coverage of Haddon's matrix Matrix elements), to support detailed coding of external cause of injury factors? Are there particular code blocks, injury mechanisms, or Haddon's elements for which documentation is particularly lacking pertinent information required to inform Haddon's Matrix? Are there key areas where clinical documentation could currently support a more detailed code structure?

RQ11 Ambulance Records: What is capacity of prehospital records to provide relevant injury causation details to enhance in-hospital data collections? To what extent does the presence of an ambulance record in the hospital chart contribute to the information quality of the overall source documentation for external cause of injury?

The impact of a lack of detailed information within source documentation upon the capacity to assign high quality codes was discussed in Section 7.2.1.2. Study Two demonstrated the resultant, particularly amongst Transport codes, how the overuse of lower quality codes can eventuate due to lack of documented detail to assign higher quality codes. To benchmark the available levels of information relating to each of the Haddon's elements, clinical documentation was reviewed in detail in Study Three using the Haddon's Matrix. There was marked variability in the availability of information across the Haddon's Matrix. Mechanism information was most prevalent (98% of cases); Host information was available somewhere in the medical documentation in 70% of all injury cases; and, Object information was available in 88% of records. Documentation of Environment information was poorest with only 52% of records containing any information. This finding is in accordance with the information quality issues that have been evidenced with the Environment element across all studies of this thesis. In addition, documentation sufficiency varied by injury type for each Haddon's element, with availability environment information ranging from 48% for 'Other' injuries to 60% for Falls cases. Likewise, Host information ranged from 58% in Falls cases to 85% for Transport-related injuries, and Object information was best documented for Transport-related cases (100%) and least documented for Falls (79%)

A lack of information within the source documentation is a limiting factor in terms of development of external cause of injury coding. The impact of code system improvements will be limited until information is available within the records to support the assignment of detailed codes. This highlights the paramount importance of investing in the development of injury documentation, in particular with regards to Environment information.

Patients with an ambulance record in their hospital chart were significantly more likely to have Host, Mechanism, Object/Perpetrator and Environment information, according to unadjusted bivariate analyses (chi square $p<.05$). Adjusted analyses (multivariable logistic regressions) were conducted to identify the independent contribution of arrival mode by ambulance to the presence of injury information in the medical records. The only model in which mode of arrival by ambulance was not retained was Mechanism of injury. However, Mechanism information had the greatest availability within all source documentation, and a ceiling effect was apparent (all values ranged between 97% and 100% Present). Given the small, yet significant difference in bivariate model, the loss of this factor from the adjusted model is potentially due in part to a lack of power.

The regression model for the presence of Host information identified a significant independent contribution of arrival mode by ambulance to the predictive power of the model, once the impact of other independent variables had been accounted for. Cases with an ambulance records were 2.4 times more likely to have present Host information, 2.5 times more likely to contain Object information, and 15.0 times more likely to contain Environment information. This finding supports the coder opinions in the survey conducted by McKenzie, Enraght-Moony, Harding et al. (McKenzie, Enraght-Moony, Harding, Walker, Waller, & Chen, 2008) regarding the utility of ambulance records for injury information. The arrival of a patient at hospital by ambulance, and therefore the presence of an ambulance record in the medical chart, is significantly associated with more information in the entire medical record. This finding provides opportunities for the development of external cause of injury information, within both prehospital and hospital data collections (discussion in Section 7.3.2).

7.2.1.3 **Priorities for Development**

The program of research was devised with the primary objective of identifying key needs and strategies for enhancing the quality of ICD-10-AM coded external cause of injury data. To inform recommendations, each of the three studies addressed research questions to identify priority areas for development:

RQ5 Can high priority code blocks for quality improvement be identified, due to a low prevalence of Haddon's elements (Host, Agent, Environment information)?

RQ7 What are the relative utilisation rates within the hospital morbidity dataset of 'high' and 'low' information quality codes, identified in Study 1? Can high priority code blocks for quality improvement be identified due to either a high prevalence or overutilisation of codes with 'Absent' Haddon's elements (Host, Agent, Environment information)

RQ8 Coding Errors: To what extent do code assignment errors contribute to: loss of information regarding a Haddon's element in the coded dataset; and, introduction of false information about a Haddon's element in the coded dataset?

RQ9 Code System Limitations: To what extent do insufficiencies within the ICD-10-AM code system contribute to information attrition in the coded dataset (compared to the base information quality level of the source documentation)? Are there key areas where clinical documentation could currently support a more detailed code structure?

RQ10 Documentation Sufficiency: What is the level of documentation sufficiency (conceptualised as coverage of Haddon's matrix Matrix elements), to support detailed coding of external cause of injury factors? Are there particular code blocks, injury mechanisms, or Haddon's elements for which documentation is particularly lacking pertinent information required to inform Haddon's Matrix? Are there key areas where clinical documentation could currently support a more detailed code structure?

RQ11 Ambulance Records: What is capacity of prehospital records to provide relevant injury causation details to enhance in-hospital data collections? To what extent does the presence of an ambulance record in the hospital chart contribute to the information quality of the overall source documentation for external cause of injury?

ICD-10-AM codes can systematically collect information regarding Host, Agent, and Environment aspects of an injury. However, completeness of coverage of these elements is inconsistent across code blocks, indicating need for further development work in this area. Across all studies wide variance in the information quality of codes was evidenced by Haddon's Matrix element and injury mechanism. These differences were found in terms of the utilisation rates of high quality codes, rates of coding error, level of information availability in clinical documentation, and contribution of code system structure to both the loss and generation of details during the translation of narrative information to coded values. This marked variability indicates a lack of consistency across the code system and cause of injury data collection sources.

Codes and code blocks with higher quality information for some or all aspects of the Haddon's elements demonstrate the theoretical capacity of ICD-10-AM to characterise external causes of injury in a systematic and comprehensive manner. However, inconsistencies across the code system are evidenced to have marked impacts on the resulting coded data. Transport-related codes, which comprise the largest section of the code system (~70%) are highly structured, with multiple aspects of the injury event (Host, Object, Mechanism & Environment) combined in a pre-coordinated manner within a single code. Consequently, there was little information loss (i.e. low false negative rates) as a result of code system limitations during the coding process. This provides some support for the role of multifaceted codes within the code system. However, this high retention of information from the original source document to the final code was accompanied by either the introduction of unsupported details or disproportionate application of lower quality codes. Thus the complex structure of interrelated elements within the Transport code block forces Coders to make a compromised selection of either including additional unsubstantiated details, or resorting to less detailed codes at the expense of excluding verified information.

By contrast, Falls related codes contain limited options (2% of code system) notwithstanding this being the most prevalent injury mechanism coded within the QHAPDC dataset. Despite relatively few code options, preferential assignment of higher information quality Falls codes was evidenced in QHAPDC, along with high false negative rates. Notably, false negative rates, or loss of information, were five times higher amongst Falls codes than Transport-related codes. These findings indicate that a more detailed code structure in this section of the classification would be supported as information attrition is currently occurring due to insufficient code options. Examination of false negatives across the entire code set indicated that Other Injuries and Environment code elements would similarly benefit most from more detailed code structure.

Comparison of the varying error rates, in terms of use of low information quality codes, information attrition and introduction of false details as a consequence of code selection highlights the importance of code structure to the quality of the resulting data. Detailed comparison of the contrasting code structures of the key Transport and Falls codes blocks demonstrates the need to undertake further development of the structure of the ICD-10-AM external cause codes. A balance must be struck between simplistic codes that are associated with loss of information in the coding process, and overly complicated codes that are associated with information introduction and forced choice of lower quality codes. Evaluation of the performance of the transport code section draws in to question the utility of entwined pre-coordinated code structures, suggesting that a similarly comprehensive but more accommodating structure is required. A similar concept is introduced by McKenzie and Fingerhut et al. (2012), who advocate for the development of a uniformed code structure across the entire code set, in an arrangement that is capable of being applied in both pre-coordinated and multidimensional modular manners. Within such a structure each Haddon's element (Host, Mechanism, Object, Environment) would reside in a specific position within the code string, enabling flexible combination of these elements, straightforward extraction, and ease of aggregation into homogenous groupings (e.g. by mechanism, object etc.). The results of this study support further development of this concept.

The most marked area in need of improvement across all studied aspects (code system sufficiency, code utilisation, coder error, documentation sufficiency), was that of the Environment element. Environment information displayed universally low information quality. Results indicate that the current source documentation systematically lack Environment aspects, and that this is exacerbated by an additional attrition of information in the process of translation to coded form due to structural constraints of the ICD-10-AM code system. Environmental information is a critical component in providing accurate description of the circumstances surrounding an injury.

An inter-agency working group established by Statistics New Zealand identified place of injury occurrence to be a particularly important aspect of external cause of injury data for improvement (Statistics New Zealand, 2012). The report identified that current Place of Occurrence codes are deficient are represent a high priority area for development. The contribution of Place of Occurrence codes to information quality in the application of a hospital morbidity dataset (QHAPDC) was not assessed due to difficulties integrating these codes with the primary external cause of injury code (as discussed in Section 6.8.1). However, it is recommended that the approach of assigning place of occurrence codes in tandem with external cause codes is a practice that should remain mandatory in the short term to ensure the critical information is not degraded. It is paramount though, to ensure completeness of capture and ease of use, further development needs to be undertaken in this area to greater integrate environment information with the core external cause of injury information.

A final overarching priority for development that was identified was that of the completeness of clinical documentation for external cause of injury information. This program of research identified a high utilisation of poor quality codes due to lack of sufficient detail within source documentation to support more detailed code assignment. It is recognised that the capacity for any code system developments to positively impact upon the quality of hospital morbidity data for external cause of injury is limited by the quality of the source documentation(McKenzie et al., 2012). Fittingly, improvement of clinical documentation for injury information was postulated by clinical coders within Australia to possess the largest potential to impact on the quality of coded external cause of injury data(McKenzie K et al., 2008). Thus, given the identified current deficiencies in clinical documentation completeness for cause of injury information, development of this aspect of the data system is paramount to the enhancement of coded external cause of injury collections.

The strong relationship that was identified between the presence of ambulance documentation and availability of information within medical records highlights, in particular, the potential to further develop and enhance utilisation of ambulance documentation for the purpose of injury research. Cause of injury information within ambulance records presents opportunities to develop a unique data collection that spans a wide range of injury acuities and capture cases that currently are omitted from hospital-based collections, and to enhance the quality of hospital external cause of morbidity data for those cases transported to hospital by ambulance. This was of particular note for the area of environment information, the area that was identified to be of highest priority for development across all aspects of the data collection and coding process.

7.3 *Implications of the research*

Limited research is available regarding the quality of ICD-10-AM coded external cause of injury data. Based upon the findings of this program of research, the primary methodology used in identified studies tends to overestimate information quality of the data for injury research. This program of research proposes a more responsive framework for dissecting and measuring the quality of external cause of injury data for the purpose of injury research. Using this method benchmarks are provided for the independent contributions of coder error, code system structure, and source documentation characteristics to information loss. These findings present a number of implications for the future development of ICD-10-AM external cause of injury codes and external cause of injury data collections, from the ambulance at the scene of the event to the end user accessing the coded hospital morbidity data for hospitalised patients.

7.3.1 Evidence based approach to classification development

ICD-10-AM external causes of injury codes are employed solely for injury prevention research purposes; therefore, it is vital to utilise a development and evaluation framework that examines their properties within this context. Current ICD-10-AM external cause of injury codes have been developed without a public health or injury prevention framework, and without an evidence base for development decisions. A revision of the external cause code section of ICD-10-AM is conducted through a consultative process, facilitated through a working group of primarily health classification experts rather than injury content experts. The proposed Haddon's framework grounds injury classification and data development in a public health framework, and provides a tool for evidence based classification and data development.

This program of research supports the use of the proposed Haddon's Matrix framework to compartmentalise data collection requirements in order to evaluate the quality of ICD external cause of injury codes, ICD coded external cause of injury data collections, and classification system development activities. The Haddon's Matrix framework could be employed as a structured, evidence-based approach for code system development. The matrix provides a method by which to dissect the code system into more manageable subgroups for review, and for input by relevant injury experts into the classification development process. Furthermore, the matrix provides a structured checklist in classification development to assess code coverage of the key injury elements.

Importantly, in addition to developing a new framework, for code system development and quality evaluation, grounded in injury prevention theory, this study provides a benchmark of current code information quality. These findings, and those of subsequent evaluations, can be used to identify high priority areas for code system and clinical documentation development. Amongst the injury prevention field there are competing interests and priorities amongst various injury research areas in terms of the precedence of both injury elements (e.g intent vs mechanism) and specific mechanism groups (e.g. falls vs. transport-related injuries). Competing interests can lead to a fracture development process that is driven more by special interests than strategy. This system provides a hierarchy for immediate development, facilitates the generation of longer term plans for code system enhancements, and enables improvements to be driven from an evidence base platform.

The timing of the completion of this program of research is of particular relevance give the current work underway to develop the ICD-11, the next revision of the International Classification of Diseases. This is the first major revision to occur in approximately 20 years, and presents an opportunity to radically revise the structure of the external cause of injury code section. Since the conduct of this study discussions have emerged regarding proposed changes for ICD-11 external causes classification. Recommendations have been made regarding the transformation of the code system to one of a uniform code structure across all mechanism blocks, with clear delineation of intent, mechanism, object/product/substance information in fixed positions within the total code string (McKenzie et al., 2012). Dissecting the ICD code string in to distinct injury elements echoes the method used in this research. The studies detailed in this thesis provide a useful and valuable framework to support and inform these proposed developments, and enhance the scientific rigour of code system developments in the area of external cause of injury.

7.3.1.1 **End User Engagement**

The concept of "fit for use" has been widely adopted in the quality literature, and is now the single most widely accepted definition of quality (Price & Shanks, 2004; Wang & Strong, 1996), p6). This conceptualisation emphasises the importance of taking a consumer viewpoint of quality, because ultimately it is the consumer who will judge whether or not a product is fit for use (Deming, 1986b; Dobyns & Crawford-Mason, 1991; Juran, 1980a). Therefore, it is crucial that the end users – injury researchers – are involved in the process of external cause of injury code development. This study, using the foundational injury prevention theoretical framework of Haddon's matrix, provides the structure for informing code system development, however the operationalisation of such requires the input of content experts to provide the detail within the codes. It is imperative that injury experts are effectively engaged in the process of classification development to provide specific content advice. This could be facilitated by using the Haddon's Matrix to dissect the code system into theoretically pertinent sections for the advice and involvement of specific injury interest working groups.

7.3.2 Documentation Constraints: Improved Source Documents for Injury Leads to Improved Quality of Coded Data

As discussed in several sections throughout this document, the quality of coded datasets is constrained by the information available on which to base the code assignments. Therefore, code system improvements, in isolation, without concurrent evaluation and improvement of documentation sources is futile. This places the development of clinical documentation sources for injury information as a paramount activity for the development of external cause of injury data hospital morbidity collections.

Existing documentation sources can be enhanced by focussing on optimising current documentation forms and processes. This would include increased and ongoing training of data collectors, the use of structure data collection proformas specific to injury that identify and mandate elements for collection, and the enhancement of graphic user interfaces (GUI) in electronic collection modalities to ensure ease and comprehensiveness of collection.

Injury data is usually obtained from data collections that were not designed specifically for injury surveillance, but for other purposes such as finance and resourcing functions. As a result, the amount and type of information that is available for injury surveillance can vary, and the information contained within is not likely to be as extensive as the information obtained from a data collection designed and dedicated to injury surveillance. Hospital morbidity data is an example of such an administrative data collection that is commonly used for injury surveillance (Graitcer, 1987). Consequently, it is not often that any one data collection will have all the information necessary to adequately describe the incidence, causal factors, and circumstances surrounding an injury event (Ing, 1985). Whilst each source of documentation can provide valuable contribution to the description of an injury's circumstances, individual data sources are limited in their ability to independently provide a complete description (Boufous, 2006). Therefore, it is necessary to focus on developing a continuum of data to inform vital injury surveillance activities.

The concept of development of a continuum of data for injury surveillance is in accordance with the Australian National Injury Prevention and Safety Promotion Plan: 2004-2014 (National Public Health Partnership, 2005), which identifies lack of quality, access to and dissemination of injury information, and fragmentation of injury prevention activities between organisations as current major gaps in injury prevention efforts (Strategic Injury Prevention Partnership, 2004). The Plan designates these factors as 'strategic pillars' of injury prevention, and calls for better coordination and co-operation between injury-related agencies.

A specific finding of this dissertation is the contribution, particularly relating to the area of environment information, and further potential to maximise the use of ambulance documentation as contributing to the body of injury causation data. "Inpatient data is greatly enhanced when supplemented with data from other health care sectors" (Schoenman, Sutton, Kintala, Love, & Maw, 2005, p.48). Ambulance and hospital facilities are important agencies in the treatment of injury, and central components of a comprehensive trauma system. Ambulance records could thereby be used to inform and enhance the capacity of hospital morbidity data collections for injury information. As such, the integration of causal injury information collected by these organisations is vital to integrated and coordinated injury prevention and control research across the continuum of acute care following injury. There are a number of corollary benefits of this proposal for injury researchers, hospital coders and ambulance services, as outlined in the following section.

7.3.2.1 **Implications for Prehospital Services**

This dissertation has established ambulance sourced documentation to be a valuable source of injury information, particularly relating to the environmental factors involved in an injury event. In Queensland, approximately 30-40% of all admitted patients arrive to hospital by ambulance (Toloo et al., 2012). Thereby, ambulance report forms present an important opportunity to enhance the coding process in-hospital, and develop an additional source of injury information for researchers. Ambulance data covers a wide spectrum of injury severities (Davey et al., 2007), from minor injury that can be treated on scene to major injuries requiring hospitalisation, and prehospital deaths. The inclusion of pre-hospital data serves to provide a more accurate dataset that captures and profiles the full range of injury types and acuities.

The interaction of the ambulance service with the patient at the scene of injury through to arrival at hospital, for transported patients, affords the ambulance service a unique opportunity to inform directly data collection regarding the pre-event, event and post-event time phases of Haddon’s matrix. Ambulance services are the first point of medical contact for many hospitalised injured patients; and are a key agent in the treatment of injury. Paramedics often have opportunity to eye witness the scene of injury event, observing and documenting vital information regarding injury causation. Greater utilisation and integration of prehospital sourced information into mainstream data collections, such as hospital morbidity data, is an important step in developing a continuum of data that will enhance data collection across the acute care system. The concept of promoting a ‘continuum of data’ for acute injury, by integrating ambulance and hospital injury aetiologic data, is in accordance with the current trend towards developing a systems approach to health care. An ongoing focus of emergency medicine is the development of integrated trauma systems, a guiding principle of which is the ‘continuum of care’.

The American Trauma Society (2002) definition of a ‘continuum of care’ promotes the inclusion of pre-hospital care (e.g., ambulance services) within a comprehensive trauma system.

> “A comprehensive trauma system consists of many different components that are integrated and coordinated to provide cost-effective services for injury prevention and patient care. At the center of this system is the continuum of care, which includes injury prevention, pre-hospital care, acute care facilities, and post-hospital care.” (American Trauma Society, 2002)

Recognising the role of emergency medical services within this continuum of care not only validates the important contribution of these agencies to the reduction of morbidity and mortality, but also validates the potential for these agencies to provide information to inform the care process. Trauma system development activities recognise that trauma is best addressed in a coordinated and systematic manner (Sharma, 2005). This process involves cooperation of professionals and resources both within and across the various organisations involved in the medical response to injury events (Ameratunga, 2004).

If healthcare is to be viewed as a continuous process, rather than a series of discrete interactions, then a continuum of data needs to be established to support this functioning. In order to completely follow a patient’s travel through acute treatment, and fully understand the factors involved from pre-injury to release from hospital, prehospital and in-hospital phases need to be accessible (Jester et al., 1993). Historically, ambulance services and hospital sectors have functioned autonomously, maintaining separate data systems that were not able to interact (Lerner, Billittier, O‘Connor, Allswede, Blackwell, Wang & White, 2005). The assemblage of isolated pools of data within organisations has hampered comprehensive injury research. Development of a continuum of data across services would aid in the development, evaluation, and improvement of trauma care across the system, enhancing patient care and facilitating cross-sectoral injury surveillance, prevention, and control research.

Presently trauma registries form the best mechanism for integrating prehospital and hospital data; however, they only measure a segment of the injured population. Generally, trauma registries only include serious injuries (ISS≥16); however, they exclude the most serious cases, those involving prehospital fatality (Pollock, 1995; Potenza et al., 2004). An American study found that of all fatalities studied, 60.3% of cases died at the scene or during transport, whilst only 23.4% died in-hospital (Potenza et al., 2004). Additionally, the impact locally of excluding prehospital deaths from trauma registries is illustrated in the National Trauma Registry Consortium (Australia & New Zealand) Report: 2002. This report records 388 road fatalities within Australia and New Zealand in 2002, whereas official road traffic crash statistics from the Australian Transport Safety Bureau (ATSB) show 1,715 deaths in Australia alone for that year. This discrepancy in the data, in excess of 77% difference, is attributed to the fact that the trauma registries do not record prehospital deaths. Thus, trauma registries may still be incomplete and nonrepresentative sources of injury surveillance data (Clark & Hahn, 1999). The exclusion of prehospital deaths from injury research has been identified as a significant information gap in injury surveillance (Sharma, 2005). Pre-hospital fatalities represent an important focus of potentially preventable deaths for injury prevention activities (Winkler, 1999). In order to address this deficiency, high-quality documentation should be a vital component of any pre-hospital trauma-care system (Sharma, 2005).

It is not just trauma registries that omit prehospital fatalities, as many population-based studies of trauma are limited by not including prehospital deaths (Demetriades et al., 1998; McNicholl & Cooke, 1995; Pickett, Hartling, & Brison, 1998). One of the largest studies of trauma outcomes conducted to-date omitted all information regarding the prehospital phase (Champion, Copes, & Sacco, 1990). This leaves a large gap in the documentation of the continuum of care for injury. Another population study of trauma outcomes that did include information on the prehospital phase failed to distinguish between deaths that occurred prior to arrival of the emergency services and those that occurred during treatment (Gorman et al., 1995). Whilst the study confirmed that the majority of deaths do occur prehospital, it was unable identify the proportion of cases that died before any treatment was received. However, a separate study reports that, in fact, most injury-related deaths occur before any treatment is able to be received (Mock, Quansah, Krishnan, Arreola-Risa, & Rivara, 2004). This is important for injury prevention as it identifies the rapidity with which fatal injuries cause death, and, therefore, highlights the importance of injury prevention.

A project by the ACT Ambulance Service implemented a Falls Prevention Program, providing a risk assessment and referral service to high-risk fallers attended by paramedics. As a consequence of this research, it was discovered that 25% (n = 229) of persons attended as a result of a fall were not transported to hospital (Yaxley, Kulh, Sullivan, & Blewitt, 2005). A similar pattern has also been evidenced by the London Ambulance Service (Marks, Daniel, & Afolabi, 2002). Currently, nothing is known about those who call an ambulance but are not transported to hospital, or those who die before arriving at hospital (Barthell, Coonan, Finnell, Pollock, & Cochrane, 2004). This group represent a large gap in injury surveillance and prevention research.

The greater recognition of the role of ambulance records in providing vital injury information, and the increased utilisation of this data source presents a unique opportunity to capture information on a wide spectrum of patient, from those treated in the field and not transported, to patients transported to the emergency department and either discharged or hospitalised, to prehospital deaths. Without the incorporation of ambulance records into data collections patients treated in the field and not transported to hospital (either due to injuries not requiring further treatment or the patient being deceased in the field) are a neglected group.

Whilst traditionally prehospital documentation was handwritten, accessibility of ambulance recorded documentation to increasing with the growth of electronic data collection. The Queensland Ambulance Service commenced statewide electronic data collection in 2007. A printed copy of the record is provided to the hospital with the patient at handover, at this is retained in the hospital chart for the reference of treating clinicians and clinical coders. Simultaneously, the ambulance service is compiling a large data warehouse of accessible case records for interrogation and analysis.

Whilst the move to electronic prehospital capture has increased the accessibility to extraction and reporting of routinely collected data, there is a need to ensure that the information richness of the collection is not lost. This thesis, based upon study of narrative text within manually completed paper-based prehospital records, identifies that ambulance records have the potential to be a useful source of injury information. As a consequence of this study, a detailed catalogue has been generated of the nature of injury information observed and collected by paramedics during the course of treatment. This rich information source could be used as a basis for informing the development of a classification system, structured around the ICD code system, for application in the prehospital field. Development and implementation of such a standardised system could enhance comparability and semantic interoperability with hospital coded collections to facilitate integration and analysis across the systems.

An additional unique aspect of modern ambulance data is the availability of geocoded location information. This enables exact positioning of the scene location against geographic mapping tools and enables identification of proximity to landmarks or facilities. This potential utility of ambulance records for geographically based injury information is supported by Backe & Andersson (2008, p.256), who were able to use this information to identify details such that “most injuries due to violence occurred at or nearby pubs, restaurants, and other amusement areas”.

Access to such specific location information is an exceptional resource and a valuable opportunity for injury researchers.

An additional and important benefit of the greater development and utilisation of ambulance derived information is the benefit to the ambulance services of greater professionalisation of the industry, and wider engagement of ambulance services with injury researchers and the general research community. Regular reliance on and promotion of ambulance records will increase the attention paid to this information source, and likely consequentially promote the further development and promotion of the value of this data source.

7.3.2.2 Improved hospital morbidity data

Improved injury documentation and external cause codes would facilitate the in-hospital coding process, and maximise the number of high quality codes that are assigned to the records. Consequently, enhanced data quality would lead to better utilisation of this dataset for injury research. If able to be achieved, this represents a more cost effective option than developing new data collections to evaluate specific issues. However, as external cause codes are not used for funding purposes, they are of low priority for hospitals and coders. Thereby, there is a need to firstly, simplify coding process so as to maximise data and information quality of hospital morbidity datasets. Secondly, it is vital that the role and importance of this data is promoted to the various agents involved in it collection, coding and application. Education and audit play a role in achieving both of these aims.

7.3.3 Education and Quality Audit

This research identified that coding errors, resulting in either the loss of gain of information regarding one or more of the Haddon's elements contributes up to a 15%

error rate, dependent upon the code block. Such inaccuracies in the data have the potential to seriously impact upon the reliability and effectiveness of injury prevention activities developed based upon the apparent evidence within this data collection.

Education and quality improvement activities are vital to any quality improvement programs. These activities need to be ongoing endeavours, with routine audit programs providing a feedback mechanism that informs the development and delivery of educational programs so as to ensure their timeliness and relevance. Education should encompass multiple aspect of the data collection, coding and analysis process.

Given the complex and varied nature of injury events and causative factors, it is important that clinical coders be provided with explicit coding rules and guidelines to direct uniform code assignment in the event of ambiguities in the code system or inconsistent documentation. Improved support and guidance at the hospital level will translate to a code system that is more suited to its application, and therefore easier for clinical coders to apply consistently.

Due to a lack funding implications for external cause of injury data, there is a lesser emphasis on the value of this data as seen by coders. It is therefore vital to educate all parties involved in the collection and coding of injury information as to the vital importance and potential impact of this data in injury research. Education must start with the clinicians responsible for recording injury information within the clinical records. Promotion of critical role of clinicians in injury prevention (via data collection) need to be highlighted through the participation of injury researchers in industry/clinical forums, and of clinicians at injury forums, so as to maintain clinician engagement in the collection of comprehensive cause of injury information within the medical chart. Given the identified utility of ambulance records for injury information it is important that paramedics are included in documentation training and professional development activities around injury prevention.

7.3.3.1 **Improved injury surveillance**

> "Precise data regarding the causes of injury on a population basis are essential for a clear delineation of the problem; identification of existing and emerging trends in injury; design of prevention strategies to ameliorate the risk of injuries; assessment of the impact of implemented countermeasures; to evaluate the effectiveness of current treatments in reducing resultant morbidity and mortality and for developing new and more effective clinical management strategies."
>
> (Mitchell et al., 2008)

Injury surveillance is the scientific endeavour of measuring trends, monitoring improvements, and identifying where to focus injury prevention efforts. This is all done to the end purpose of reducing the toll of injury on the community and the healthcare system. The potential for successful injury prevention strategies to significantly impact upon the physical, emotional and financial consequences of injuries attests to the importance of this endeavour, and the value of investing in supporting these vital activities.

7.4 *Strengths and limitations of the research*

The specific strengths and limitations of the three studies within this research program were addressed in the relevant chapters of this thesis. Presented following is a discussion of the key strengths and limitations of the overall program of research.

There is a dearth of studies evaluating the quality of ICD-10-AM codes. Those that are available focus on evaluating data quality aspects of datasets coded with ICD-10-AM in terms of coder agreement and coding completeness, there has been little evaluation of the quality of the underlying code system (only the codes in application). This program of research provides a test for the concept of operationalisation of Haddon's Matrix to facilitate detailed evaluation of injury information quality, and the 'fit-for-purpose; of ICD-10-AM external cause of injury codes for injury prevention research. Importantly, this framework enables the use of epidemiological analysis methods (i.e., completeness of coverage, specificity, false positive, false negatives) to conduct rigorous evaluations of code and classification system structure.

This doctoral thesis was conducted as a part of a larger Australian Research Council (ARC) funded project to examine and enhance the quality of hospital morbidity data for external cause of injury information. The larger study undertook the detail medical record review on a national basis, to examine sources of coding discrepancy between the original and auditor code. Agreement between original and audited codes was examined for:

- Intent (e.g. unintentional, assault etc.)
- External cause category (e.g. transport, fall etc.)
- Specificity agreement (e.g. specified vs not specified)
- Code digit agreement (agreement to 3rd, 4th, or 5th character level)

The most common variance was for external cause of injury mechanism code block assigned, with 9.5% of cases differing. Notably, assigned injury intent differed in 3.7% of cases (McKenzie & McClure, 2010). Whilst the McKenzie & McClure (2010) paper provides an interesting description and quantification of nature of code variances between the original hospital assigned code and that of an expert auditor, no exploration was provided of the causes of these variations. However, the authors did provide a number of recommendations to help minimise coding discrepancies:

1. Improving the quality of medical documentation
2. Improving coder training
3. Developing clearer data definitions and standards for external cause coding
4. Increase end-user awareness of strengths and weaknesses of ICD-10-AM external cause codes.

In order to best direct efforts to strategies that will have the greatest impact on improving the utility of hospital external cause of injury morbidity data, it is necessary to identify and quantify the contributions of various error sources to the overall quality of the resultant coded dataset. This was a key purpose of the work described in this thesis.

This study is the first to employ a single evaluation framework, based upon foundational injury prevention theory, to measure the influence of three key aspects of the clinical coding process (source documentation, code assignment, and code system structure) on the quality of the resultant coded data. The study proposes a novel framework to support the detailed and systematic evaluation of fit-for-purpose of injury codes and medical documentation for the purpose of injury research. The use of Haddon's Matrix, a foundational injury prevention theory, extends the evaluation of quality beyond a simple data completeness or coder agreement measure to an evaluation of the utility of the provided information for the purpose of injury research. This methodology enables quantification the relative contributions of different sources of error to overall information quality and enables identification of priorities for improvement – both in terms of priority code blocks and injury elements for development, and the most impactful improvement measures.

The novel use of a medical record review methodology and the development of the Haddon's Matrix framework to support systematic analysis of the code system is a unique contribution of this doctoral thesis. The findings provide benchmarks for the contributions of several error sources, and are noteworthy for informing strategies for quality improvement.

This program of research employed the proposed Haddon's Matrix on a dichotomised basis (present/absent) for a single item of information relating to each of the Haddon's elements. This was conducted as a test of the framework. This application did not enable the identification of multiple present details relating to an individual element. In addition, no quality judgement was made as to the relative value or importance of the particular detail to the description of the injury event. It was beyond the scope of the current study to evaluate the relative value of each textual element contained within each code. There are in excess of 2200 external cause of injury codes within the ICD-10-AM system content specific analysis of each code is a sizable and highly content specific activity. Conduct of this detailed subject specific analysis would require the input of multiple experts to provide value assessment across multiple injury interest areas.

Additionally, for the hospital morbidity data analysis (Study 2) only one external cause code per patient could be examined, despite the capacity to record multiple codes within the medical record. There is the potential that further codes, where present, may have contained additional injury information to the primary external cause of injury code. However, it was established that in the majority of cases only one external cause code was present, thereby minimising the potential impact of exclusion of additional external cause codes on the results of this study

The hospital morbidity dataset analysis in Study 2 involved application of the Haddon's Matrix framework to a coded dataset. The structuring of place of occurrence and activity codes as separate items to the main external cause code presented a complication. Linking associated external cause of injury, place of occurrence and activity codes within the QHAPDC dataset is problematic as the order of codes is not always retained during the processing of this dataset. Additionally, it was not feasible, with in excess of 2,500 external cause of injury codes, to evaluate each of this in combination with every Place of Occurrence and Activity code. For this reason, in the hospital morbidity dataset analysis, Place of Occurrence and Activity codes were not consolidated with the external cause of injury code to assess in combination for the presence of environmental or host information. This may have led to an underestimation of the presence of pertinent injury information (such as Environment information contained within the Place of Occurrence codes) in the coded record, however it does provide an accurate profile of the value of the most consistently utilised portion of the code system, the external cause of injury codes. However, during the detailed medical record review study narrative information relating to place of occurrence and activity aspects

Similarly, some information regarding Host factors may be collected in other sections of the medical record, as opposed to within the external cause of injury codes (eg. demographic sections). Due the structure of clinical record systems, this information is stored in discrete variables and does not get systematically incorporated into the external cause collection. The purpose of this study was specifically to evaluate the information quality of ICD-10-AM external cause of injury codes, as a dedicated collection of cause of injury information. It is for this reason that information from field outside of the ICD-10-AM cause of injury codes was not incorporated into the assessment for this study.

This dissertation is also the first research to comprehensively evaluate the quality of ambulance documentation for external cause of injury information. Whilst there has been postulation as to the potential value of these records for injury information, and limited evaluation around specific injury issues, there has not to date been an encompassing evaluation across the spectrum of injury mechanisms. This study validates the utility of ambulance records for cause of injury information, and provides support for the greater involvement of ambulance sourced data in injury research activities.

The analysis of ambulance records was conducted on paper records, which are no longer in use within the ambulance service. The benefit of studying the paper-based records is that these forms are richer in text than electronic ambulance report forms that rely on constrained pick list fields. In electronic data collection mediums narrative is restricted as it is time consuming to enter and not amenable to analysis and reporting. The use of unconstrained narrative enabled a benchmark to be established of the standard of injury detail collected by paramedics. Analysis of this rich narrative may be used to guide development of suitable data structures for electronic data collection. This is of importance as it is imperative to ensure that the richness of this data source is not lost with change to electronic collection.

Whilst this study was conducted using medical records and hospital morbidity data from Queensland hospitals (Australia), the findings have wider implications to many health systems around the world. ICD-10-AM, in use throughout Australia, is the most commonly-used healthcare classification system internationally and has been implemented in many countries across Europe and around the world. The findings have wide implications, and provide direct benchmarks for all countries that employ the ICD-10-AM code system. In addition, the proposed Haddon's Matrix framework may be adapted and applied to other injury classification systems and data structure to assess their "fit-for-purpose" for injury research.

With ICD-11 developments looming, this research is timely in providing an evidence-based approach for redevelopment of the classification system, to introduce a strong theoretical framework for the external causes chapter, and to enable epidemiological evaluation of the performance of the code system for the end purpose of injury research.

7.5 *Concluding remarks*

Despite the enormousness of its toll, injury prevention and trauma care receive little attention and funding relative to other health issues. A lack of robust, quality data by which to measure and describe the occurrence and toll of injury, may suggest one possible explanation for the mismatch between health impact and health care dollars spent (NPHP, 2005). Poor data quality has the capacity to constrain the quality of any information derived from that data; therefore data quality can be considered a key component of information quality. However, data quality alone neglects important elements of overall information quality (e.g. just how useful information is to users) (NHS, 2004). Whilst the absolute attributes of data are important, it is how those attributes are perceived that defines the information quality. To this end, a novel approach to quantifying the "fit-for-purpose" of injury data was developed based upon the foundational injury prevention framework, Haddon's Matrix.

Haddon's Matrix and injury prevention are public health, and specifically epidemiological, activities. The utilisation of this proposed Haddon's framework for injury data evaluation grounds classification development in a public health framework, and enables the use of epidemiological analysis methods (i.e., completeness of coverage, specificity, false positive, false negatives) to conduct more rigorous evaluations of code and classification system structure. The Haddon's framework, which provides discrete assessments of code quality by key theoretical aspects, displayed equivalent completeness of coverage (proxy sensitivity) to the Defined/Undefined code categorisations. However, the Defined/Undefined method had far lower specificity. These results indicate that the Haddon's Matrix better reflects the complexity of the ICD code system for injury information. Use of crude Defined/Undefined code categorisations resulted in an inflated assessment of ICD-10-AM code system quality, which conflicts with widely reported limitations of the ICD external cause of injury coding system. It is asserted that the Haddon's Matrix conceptualisation of information quality, which has been grounded in relevant injury theory, should be used in preference as a more accurate measure of the quality of injury data.

Haddon's Matrix provided a functional and systematic framework by which to dissect the ICD-10-AM codes into discrete, manageable segments of information that better reflect the multidimensional nature of these codes. This enables more thorough evaluation of the coverage of key injury concepts to ensure that the codes are structured to collect quality information key aspects of an injury event that are vital for the identification and design of prevention strategies. This methodology presents opportunities to inform and guide injury classification development activities, and provides a mechanism by which priorities for development can be identified.

Key priorities for future development and further research were identified across the three studies that comprise this program of research. High priority areas for addressing are:

1) the consistency of code structure to improve capture of injury information and decrease information attrition due to code system constraints;

2) availability and coding of Environment information, which was found to be universally lacking in terms of coder accuracy; sufficiency of the code structure to adequately capture; utilisation of codes with present environment information; and completeness of source documentation for this information element;

3) improvement in terms of the completeness of source documentation for external cause of injury information;

4) the need for expert input into the development and content of codes to extend the application beyond a present/absent determination. The Haddon's matrix

framework provides a structured epidemiological tool for the development and analysis of external cause of injury codes, however detailed content-specific injury research expertise is required for the next phase of development to extend this model beyond a structural instrument and embed content specific knowledge in the application of this tool in evaluating the information quality of injury coded data and documentation.

Finally, this research is unique in its focus on the role of ambulance in supporting the collection and coding of external cause of injury information. There are no previous studies comprehensively evaluating the quality of ambulance documentation for external cause of injury information. This study is the first to quantify the value of ambulance acquired injury causation information to the information quality of hospital data collections, and provides support for the greater involvement of ambulance sourced data in injury research activities.

The enhancement of external cause of injury data will lead to an improved evidence base for injury prevention, countermeasure design and resource planning. In a healthcare system increasingly focussed on cost effectiveness, improved information regarding the occurrence and impact of injuries is vital to lead stronger political movements to support the funding and resourcing of injury prevention activities to reduce the financial, social and emotional impact of injury on the health system and the community.

"If a disease were killing in the proportions that injuries are, people would be outraged and demand that this killer be stopped."

(Former Surgeon General C. Everett Koop, MD)

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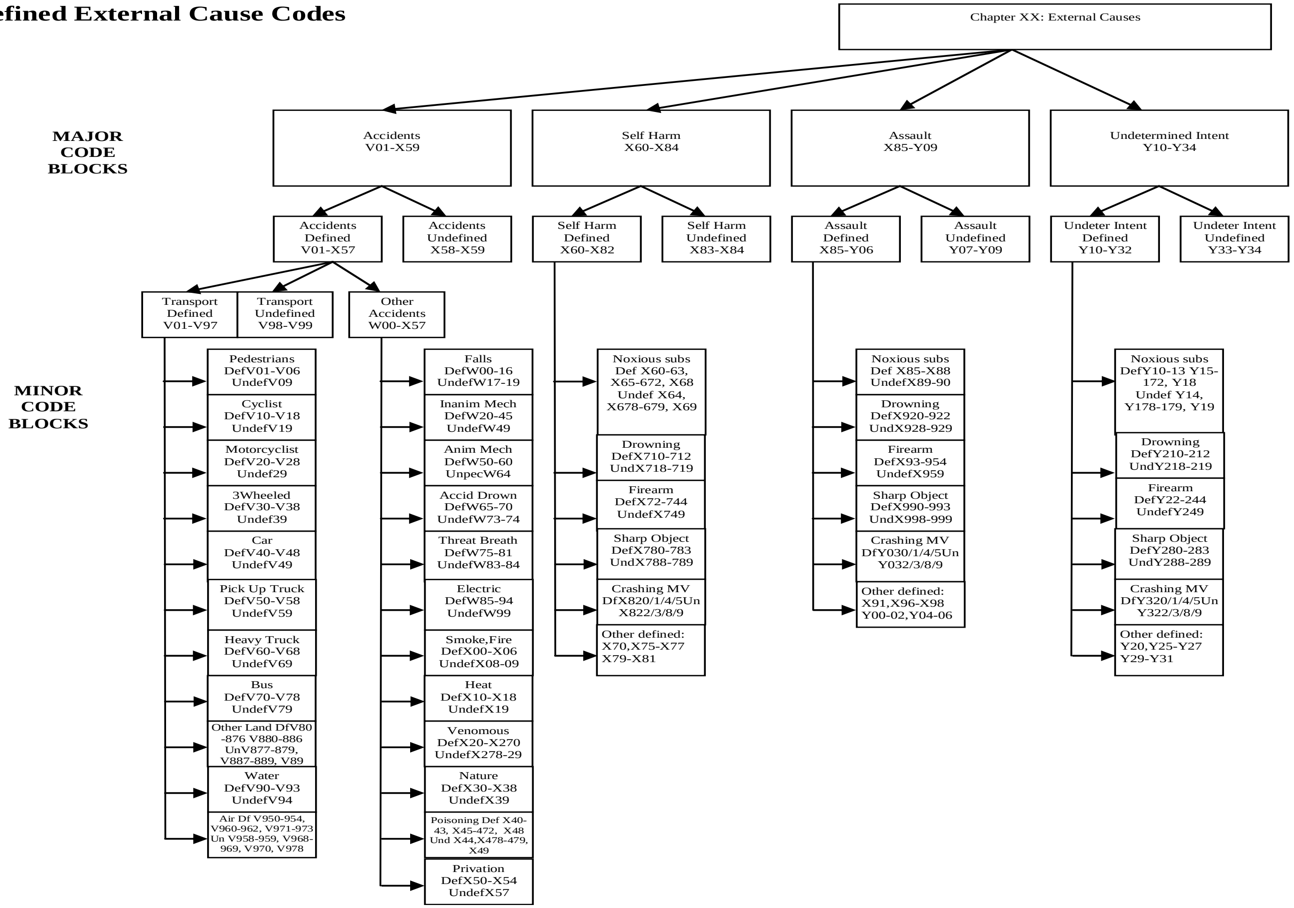
APPENDIX 1 DEFINED/UNDEFINED CODE DIAGRAMS

Defined/Undefined External Cause Codes



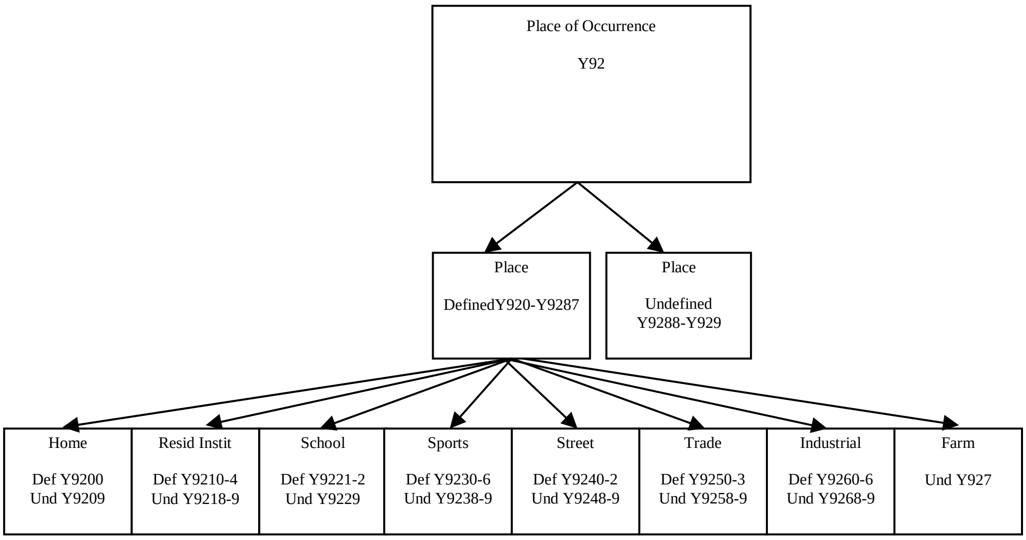
Defined/Undefined Codes At Major And Minor Code Block Level In External Cause Chapter

Description	**Defined Code Blocks**	**Undefined Code Blocks**
ACCIDENTS	**V01-X57**	**X58-X59**
Transport Accidents	**V01-V97**	**V98-V99**
Pedestrians *4th Character: Traffic/Non Traffic*	V01-V06 *V01-06(0-1)*	V09 *V01-06(9)*
Pedal cyclist *4th Character: Driver/Pass*	V10-V18 *V10-18(0-1,3-5)*	V19 *V10-18(2,9)*
Motor cyclist *4th Character: Driver/Pass* *5th Character: Vehicle Type*	V20-V28 *V20-V28(0-1,3-5)* *V20-V28(0-2)*	V29 *V20-V28(2,9)* *V20-V28(8-9)*
Occupant three wheeled motor vehicle *4th Character: Driver/Pass*	V30-V38 *V30-V38(0-2,4-7)*	V39 *V30-V38(3,9)*
Occupant car *4th Character: Driver/Pass* *5th Character: Vehicle Type*	V40-V48 *V40-V48(0-2,4-7)* *V40-V48(0-3)*	V49 *V40-V48(3,9)* *V40-V48(8-9)*
Occupant pick-up truck or van *4th Character: Driver/Pass*	V50-V58 *V50-V58(0-2,4-7)*	V59 *V50-V58(3,9)*
Occupant heavy transport vehicle *4th Character: Driver/Pass*	V60-V68 *V60-V68(0-2,4-7)*	V69 *V60-V68(3,9)*
Occupant bus *4th Character: Driver/Pass*	V70-V78 *V70-V78(0-2,4-7)*	V79 *V70-V78(3,9)*

Other land trans accidents	V80-876 V880-886	V877-879, V887-889, V89
4th Character	*V80 (0-4,6,8)* *V81-82 (0-7)* *V83-86 (0-2,4-7)* *V87 (0-6)*	*V80 (5,7,9)* *V81-82 (8-9)* *V83-86 (3,9)* *V87 (7-9)*
5th Character	*V86(0-2)*	*V86(9)*
Water transport accidents *4th Character: Vehicle Type*	V90-V93 *V90-94 (0-2,4-7)*	V94 *V90-94 (3,8-9)*
Air and space trans accidents	V950-954, V960-962, V971-973	V958-959, V968-969, V970, V978
Other External Causes of Accidents		
Falls	W00-W16	W17-19
Exposure to inanimate mechanical forces	W20-W45	W49
Exposure to animate mechanical forces	W50-W60	W64
Accidental drowning and submersion	W65-W70	W73-W74
Other accidental threats to breathing	W75-W81	W83-W84
Exposure to electric current, radiation	W85-W94	W99
Exposure to smoke, fire, flames	X00-X06	X08-X09
Contact with heat and hot substances	X10-X18	X19
Contact venomous animals or plants	X20-X270	X278-X29
Exposure to forces of nature	X30-X38	X39
Accidental poisoning by noxious substances	X40-43, X45-472, X48	X44, X478-479, X49
Overexertion, travel,privation	X50-X54	X57

INTENT SELF HARM	**X60-X82**	**X83-X84**
Exposure to noxious substances	X60-X63, X65-X672, X68	X64, X678-X679, X69
Drowning	X710-X712	X718-X719
Firearm discharge	X72-X744	X749
Sharp object	X780-X783	X788-X789
Crashing MV	X820/821/824/825	X822/823/828/829
Other defined	X70, X75-X77, X79-X81	
ASSAULT *5th Character: Perpetrator*	**X85-Y06** *X85-Y09 (0-7)*	**Y07-Y09** *X85-Y09 (8-9)*
Exposure to noxious substance	X85-X88	X89-X90
Drowning	X920-X922	X928-X929
Firearm discharge	X93-X954	X959
Sharp object	X990-X993	X998-X999
Crashing MV	Y030/031/034/035	Y032/033/038/039
Other defined	X91, X96-X98, Y00-Y02, Y04-06	
UNDETERMINED INTENT	**Y10-Y32**	**Y33-Y34**
Exposure to noxious substances	Y10-Y13,Y15-Y172, Y18	Y14, Y178-Y179, Y19
Drowning	Y210-Y212	Y218-Y219
Firearm discharge	Y22-Y244	Y249
Sharp object	Y280-Y283	Y288-Y289
Crashing MV	Y320/321/324/325	Y322/323/328/329
Other defined	Y20, Y25-Y27, Y29-Y31	

PLACE OF OCCURRENCE CODES



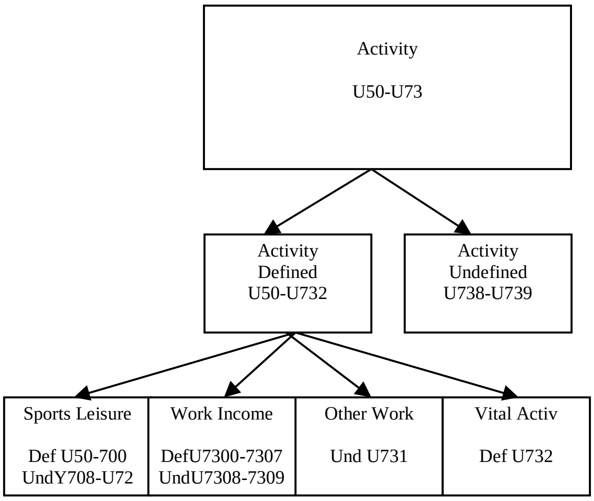
Code ID	Text Descriptor	Data Quality
Y92.0	Home	Defined
Y92.00	Driveway to home	Defined
Y92.09	Other and unspecified place in home	Undefined
Y92.1	Residential institution	Defined
Y92.10	Residential institution, prison	Defined
Y92.11	Residential institution, juvenile detention centre	Defined
Y92.12	Residential institution, military camp	Defined
Y92.13	Residential institution, orphanage	Defined
Y92.14	Residential institution, aged care facilities	Defined

Y92.18	Other specified residential institution	Undefined
Y92.19	Unspecified residential institution	Undefined
Y92.2	School, other institution and public administrative area	Defined
Y92.21	School	Defined
Y92.22	Health service area	Defined
Y92.29	Other specified institution and public administrative area	Undefined
Y92.3	Sports and athletics area	Defined
Y92.30	Sports and athletics area, sporting grounds (outdoor)	Defined
Y92.31	Sports and athletics area, sporting hall (indoor)	Defined
Y92.32	Sports and athletics area, swimming centre	Defined
Y92.33	Sports and athletics area, racetrack and racecourse	Defined
Y92.34	Sports and athletics area, equestrian facility	Defined
Y92.35	Sports and athletics area, skating rink	Defined
Y92.36	Sports and athletics area, skiing	Defined
Y92.38	Other specified sports and athletics area	Undefined
Y92.39	Sports and athletics area, unspecified	Undefined
Y92.4	Street and highway	Defined

Y92.40	Street and highway, roadway	Defined
Y92.41	Street and highway, sidewalk	Defined
Y92.42	Street and highway, cycleway	Defined
Y92.48	Other specified public highway, street or road	Undefined
Y92.49	Unspecified public highway, street or road	Undefined
Y92.5	Trade and service area	Defined
Y92.50	Trade and service area, shop and store	Defined
Y92.51	Trade and service area, commercial garage	Defined
Y92.52	Trade and service area, office building	Defined
Y92.53	Trade and service area, cafÚ, hotel and restaurant	Defined
Y92.58	Other specified trade and service area	Undefined
Y92.59	Unspecified trade and service area	Undefined
Y92.6	Industrial and construction area	Defined
Y92.60	Industrial and construction area, construction area	Defined
Y92.61	Industrial and construction area, demolition site	Defined
Y92.62	Industrial and construction area, factory and plant	Defined
Y92.63	Industrial and construction area, mine and quarry	Defined

Y92.64	Industrial and construction area, oil and gas extraction	Defined
Y92.65	Industrial and construction area, shipyard	Defined
Y92.66	Industrial and construction area, power station	Defined
Y92.68	Other specified industrial and construction area	Undefined
Y92.69	Unspecified industrial and construction area	Undefined
Y92.7	Farm	Undefined
Y92.8	Other specified place of occurrence	Undefined
Y92.80	Other specified place of occurrence, area of still water	Undefined
Y92.81	Other specified place of occurrence, stream of water	Undefined
Y92.82	Other specified place of occurrence, large area of water	Undefined
Y92.83	Other specified place of occurrence, beach	Undefined
Y92.84	Other specified place of occurrence, forest	Undefined
Y92.85	Other specified place of occurrence, desert	Undefined
Y92.86	Other specified place of occurrence, other specified countryside	Undefined
Y92.87	Other specified place of occurrence, parking lot	Undefined
Y92.88	Other specified place of occurrence	Undefined
Y92.9	Unspecified place of occurrence	Undefined

ACTIVITY CODES



Code ID	Text Descriptor	Data Quality
U50	Team ball sports	Defined
U50.0	Football	Defined
U50.00	Australian Rules	Defined
U50.01	Rugby Union	Defined
U50.02	Rugby League	Defined
U50.03	Rugby, unspecified	Defined
U50.04	Soccer	Defined
U50.05	Touch football	Defined
U50.08	Other specified football	Defined
U50.09	Football, unspecified	Defined
U50.1	Basketball	Defined
U50.2	Handball, team	Defined
U50.3	Netball	Defined
U50.30	Netball, indoor	Defined
U50.39	Netball, other and unspecified	Defined
U50.4	Korfball	Defined
U50.5	Volleyball	Defined
U50.8	Other specified team ball sport	Defined
U50.9	Unspecified team ball sport	Defined
U51	Team bat or stick sports	Defined
U51.0	Baseball	Defined
U51.1	Cricket	Defined
U51.2	Hockey	Defined
U51.20	Hockey, ice	Defined
U51.21	Hockey, street and ball	Defined
U51.22	Hockey, field	Defined

U51.23	Hockey, floor	Defined
U51.28	Other specified hockey	Defined
U51.29	Hockey, unspecified	Defined
U51.3	Softball	Defined
U51.4	T-ball	Defined
U51.8	Other specified team bat or stick sport	Defined
U51.9	Unspecified team bat or stick sport	Defined
U52	Team water sports	Defined
U52.0	Synchronised swimming	Defined
U52.1	Water polo	Defined
U52.8	Other specified team water sport	Defined
U52.9	Unspecified team water sport	Defined
U53	Boating sports	Defined
U53.0	Canoeing	Defined
U53.1	Jet skiing	Defined
U53.2	Kayaking	Defined
U53.3	Power boat racing	Defined
U53.4	Rowing and sculling	Defined
U53.5	Surf boating	Defined
U53.6	Yachting and sailing	Defined
U53.7	Surf skiing	Defined
U53.8	Other specified boating sport	Defined
U53.9	Unspecified boating sport	Defined
U54	Individual water sports	Defined
U54.0	Diving	Defined
U54.00	Diving, cliff	Defined
U54.01	Diving, springboard	Defined

U54.02	Diving, platform	Defined
U54.08	Other specified diving	Defined
U54.09	Diving, unspecified	Defined
U54.1	Fishing	Defined
U54.10	Rock fishing	Defined
U54.18	Other specified fishing	Defined
U54.19	Fishing, unspecified	Defined
U54.2	Scuba diving	Defined
U54.3	Snorkelling	Defined
U54.4	Surfing and boogie boarding	Defined
U54.5	Swimming	Defined
U54.50	Swimming, competitive	Defined
U54.51	Swimming, recreational	Defined
U54.59	Swimming, unspecified	Defined
U54.6	Water skiing	Defined
U54.7	Wind surfing	Defined
U54.8	Other specified individual water sport	Defined
U54.9	Unspecified individual water sport	Defined
U55	Ice and snow sports	Defined
U55.0	Bobsledding	Defined
U55.1	Ice skating and ice dancing	Defined
U55.2	Skiing	Defined
U55.20	Skiing, alpine and downhill	Defined
U55.21	Skiing, Nordic and cross country	Defined
U55.22	Skiing, freestyle	Defined
U55.23	Skiing, snow ski jumping	Defined
U55.28	Other specified skiing	Defined

U55.29	Skiing, unspecified	Defined
U55.3	Snowmobiling	Defined
U55.4	Snow boarding	Defined
U55.5	Speed skating	Defined
U55.6	Tobogganing	Defined
U55.7	Curling	Defined
U55.8	Other specified ice or snow sport	Defined
U55.9	Unspecified ice or snow sport	Defined
U56	Individual athletic activities	Defined
U56.0	Aerobics and calisthenics	Defined
U56.00	Aerobics	Defined
U56.01	Calisthenics	Defined
U56.1	Jogging and running	Defined
U56.2	Walking	Defined
U56.3	Track and field	Defined
U56.30	Racing over obstacles and hurdles	Defined
U56.31	Track and field, sprinting and middle distance	Defined
U56.32	Track and field, running long distances	Defined
U56.33	Track and field, high jump	Defined
U56.34	Track and field, long jump	Defined
U56.35	Track and field, pole vault	Defined
U56.36	Track and field, triple jump	Defined
U56.37	Track and field, throwing events	Defined
U56.38	Other specified track and field	Defined
U56.39	Track and field, unspecified	Defined
U56.4	Walking, competitive	Defined
U56.5	Marathon running	Defined

U56.8	Other specified individual athletic activity	Defined
U56.9	Unspecified individual athletic activity	Defined
U57	Acrobatic sports	Defined
U57.0	Gymnastics	Defined
U57.00	Gymnastics, balance beam	Defined
U57.01	Gymnastics, floor	Defined
U57.02	Gymnastics, high bar	Defined
U57.03	Gymnastics, parallel bars	Defined
U57.04	Gymnastics, rings	Defined
U57.05	Gymnastics, side horse and pommel horse	Defined
U57.06	Gymnastics, trampoline and mini-trampoline	Defined
U57.07	Gymnastics, vault	Defined
U57.08	Other specified gymnastics	Defined
U57.09	Gymnastics, unspecified	Defined
U57.8	Other specified acrobatic sport	Defined
U57.9	Unspecified acrobatic sport	Defined
U58	Aesthetic activities	Defined
U58.0	Dancing	Defined
U58.8	Other specified aesthetic sport	Defined
U58.9	Unspecified aesthetic sport	Defined
U59	Racquet sports	Defined
U59.0	Badminton	Defined
U59.1	Racquetball	Defined
U59.2	Squash	Defined
U59.3	Table tennis and Ping-Pong	Defined
U59.4	Tennis	Defined
U59.8	Other specified racquet sport	Defined

U59.9	Unspecified racquet sport	Defined
U60	Target and precision sports	Defined
U60.0	Archery	Defined
U60.1	Billiards, pool and snooker	Defined
U60.2	Bowling	Defined
U60.20	Lawn bowling	Defined
U60.21	Tenpin bowling	Defined
U60.22	Indoor bowling	Defined
U60.29	Bowling, other and unspecified	Defined
U60.3	Croquet	Defined
U60.4	Darts	Defined
U60.5	Golf	Defined
U60.6	Firearm shooting	Defined
U60.8	Other specified target and precision sport	Defined
U60.9	Unspecified target and precision sports	Defined
U61	Combative sports	Defined
U61.0	Aikido	Defined
U61.1	Boxing	Defined
U61.2	Fencing	Defined
U61.3	Martial arts	Defined
U61.30	Judo	Defined
U61.31	Jujitsu	Defined
U61.32	Karate	Defined
U61.33	Kendo	Defined
U61.34	Kick-boxing	Defined
U61.35	Kung fu	Defined
U61.36	Tae kwon do	Defined

U61.38	Other specified martial arts	Defined
U61.39	Martial arts, unspecified	Defined
U61.4	Wrestling	Defined
U61.40	Wrestling, freestyle	Defined
U61.41	Wrestling, Greco-Roman	Defined
U61.42	Wrestling, professional	Defined
U61.48	Other specified wrestling	Defined
U61.49	Wrestling, unspecified	Defined
U61.5	Self defence training	Defined
U61.8	Other specified combative sport	Defined
U61.9	Unspecified combative sport	Defined
U62	Power sports	Defined
U62.0	Power lifting	Defined
U62.1	Weight lifting	Defined
U62.3	Strength training and body building	Defined
U62.4	Wood chopping	Defined
U62.5	Wood sawing	Defined
U62.8	Other specified power sport	Defined
U62.9	Unspecified power sport	Defined
U63	Equestrian activities	Defined
U63.0	Equestrian events	Defined
U63.01	Dressage	Defined
U63.02	Show jumping	Defined
U63.03	Steeplechase	Defined
U63.08	Other specified equestrian event	Defined
U63.09	Equestrian event, unspecified	Defined
U63.1	Endurance riding	Defined

U63.2	Polo and polocrosse	Defined
U63.3	Horse racing	Defined
U63.4	Rodeo	Defined
U63.5	Trail or general horseback riding	Defined
U63.6	Trotting and harness	Defined
U63.8	Other specified equestrian activity	Defined
U63.9	Unspecified equestrian activity	Defined
U64	Adventure sports	Defined
U64.0	Abseiling and rappelling	Defined
U64.1	Hiking	Defined
U64.2	Mountaineering	Defined
U64.3	Orienteering and rogaining	Defined
U64.4	River rafting	Defined
U64.5	White-water rafting	Defined
U64.6	Rock climbing	Defined
U64.7	Bungy jumping	Defined
U64.8	Other specified adventure sport	Defined
U64.9	Unspecified adventure sport	Defined
U65	Wheeled motor sports	Defined
U65.0	Riding an all-terrain vehicle (ATV)	Defined
U65.1	Motorcycling	Defined
U65.2	Motor car racing	Defined
U65.3	Go-carting	Defined
U65.8	Other specified motor sport	Defined
U65.9	Unspecified motor sport	Defined
U66	Wheeled non-motored sports	Defined
U66.0	Cycling	Defined

U66.00	Cycling, BMX	Defined
U66.01	Cycling, mountain	Defined
U66.02	Cycling, road	Defined
U66.03	Cycling, track and velodrome	Defined
U66.08	Other specified cycling	Defined
U66.09	Cycling, unspecified	Defined
U66.1	In-line skating and rollerblading	Defined
U66.2	Roller skating	Defined
U66.3	Skate boarding	Defined
U66.4	Scooter riding	Defined
U66.40	Scooter riding, folding non-motored scooter	Defined
U66.49	Scooter riding, other and unspecified non-motored scooter	Defined
U66.8	Other specified wheeled non-motored sport	Defined
U66.9	Unspecified wheeled non-motored sport	Defined
U67	Multidiscipline sports	Defined
U67.0	Biathlon, winter	Defined
U67.1	Decathlon	Defined
U67.2	Heptathlon	Defined
U67.3	Modern Pentathlon	Defined
U67.4	Triathlon	Defined
U67.40	Triathlon, cycling event	Defined
U67.41	Triathlon, running event	Defined
U67.42	Triathlon, swimming event	Defined
U67.49	Triathlon, unspecified event	Defined
U67.8	Other specified multidiscipline sport	Defined
U67.9	Unspecified multidiscipline sport	Defined

U68	Aero sports	Defined
U68.1	Aerobatics	Defined
U68.2	Gliding	Defined
U68.3	Hang gliding	Defined
U68.4	Parachuting and sky diving	Defined
U68.5	Paragliding and parasailing	Defined
U68.6	Hot air ballooning	Defined
U68.8	Other specified aero sport	Defined
U68.9	Unspecified aero sport	Defined
U69	Other school-related recreational activities	Defined
U69.0	School physical education class	Defined
U69.1	School free play	Defined
U69.8	Other specified school-related recreational activity	Defined
U69.9	Unspecified school-related recreational activity	Defined
U70	Other specified sport and exercise activity	Defined
U70.0	Athletic activities involving fitness equipment, not elsewhere classified	Defined
U70.8	Other specified sport and exercise activity	Undefined
U71	Unspecified sport and exercise activity	Undefined
U72	Leisure activity, not elsewhere classified	Undefined
U73	Other activity	Undefined
U73.0	While working for income	Defined
U73.00	Agriculture, forestry and fishing	Defined
U73.01	Mining	Defined
U73.02	Manufacturing	Defined
U73.03	Construction	Defined
U73.04	Wholesale and retail trade	Defined

U73.05	Transport and storage	Defined
U73.06	Government administration and defence	Defined
U73.07	Health services	Defined
U73.08	Other specified work for income	Undefined
U73.09	While working for income, unspecified	Undefined
U73.1	While engaged in other types of work	Defined
U73.2	While resting, sleeping, eating or engaging in other vital activities	Defined
U73.8	Other specified activity	Undefined
U73.9	Unspecified activity	Undefined

APPENDIX 2 EXTERNAL CAUSE OF INJURY MORTALITY CODE MATRIX

External Cause of Injury Mortality Matrix for ICD-10

				Intent		
	All injury	**Unintentional**	**Suicide**	**Homicide**	**Undetermined**	**Legal intervention/war**
Mechanism						
All injury	V01-Y36, Y85-Y87, Y89, ***U01-*U03**	V01-X59 , Y85-Y86	X60-X84,Y87.0, ***U03**	X85-Y09,Y87.1,***U01-*U02**	Y10-Y34,Y87.2, Y89.9	Y35-Y36, Y89(.0, .1)
Cut/pierce	W25-W29, W45, X78, X99, Y28, Y35.4	W25-W29, W45	X78	X99	Y28	Y35.4
Drowning	W65-W74, X71, X92, Y21	W65-W74	X71	X92	Y21	
Fall	W00-W19, X80, Y01, Y30	W00-W19	X80	Y01	Y30	
Fire/ hot object or substance	X00-X19, X76-77, X97-X98, Y26-Y27, Y36.3, ***U01.3**	X00-X19	X76-X77	X97-X98,***U01.3**	Y26-Y27	Y36.3
Fire/flame	X00-X09, X76, X97, Y26	X00-X09	X76	X97	Y26	
Hot object/substance	X10-X19, X77, X98, Y27	X10-X19	X77	X98	Y27	
Firearm	W32-W34, X72-X74, X93-X95, Y22-Y24, Y35.0, ***U01.4**	W32-W34	X72-X74	X93-X95, ***U01.4**	Y22-Y24	Y35.0
Machinery	W24, W30-W31	W24, W30-W31				
All Transport	V01-V99, X82, Y03, Y32, Y36.1, ***U01.1**	V01-V99	X82	Y03, ***U01.1**	Y32	Y36.1
Motor Vehicle Traffic						
Occupant	V30-V39 (.4-.9)	V30-V39 (.4-.9)				
	V40-V49 (.4-.9)	V40-V49 (.4-.9)				
	V50-V59 (.4-.9)	V50-V59 (.4-.9)				
	V60-V69 (.4-.9)	V60-V69 (.4-.9)				
	V70-V79 (.4-.9)	V70-V79 (.4-.9)				
	V83-V86 (.0-.3)	V83-V86 (.0-.3)				
Motorcyclist	V20-V28 (.3-.9), V29 (.4-.9)	V20-V28 (.3-.9), V29 (.4-.9)				
Pedal cyclist	V12-V14 (.3-.9) , V19 (.4-.6)	V12-V14 (.3-.9) , V19 (.4-.6)				
Pedestrian	V02-V04 (.1, .9) V09.2	V02-V04 (.1, .9) V09.2				
Other	V80 (.3-.5), V81.1, V82.1	V80 (.3-.5), V81.1, V82.1				
Unspecified	V87(.0-.8), V89.2	V87(.0-.8), V89.2				
Pedal cyclist, other	V10-V11, V12-V14 (.0-.2)	V10-V11, V12-V14 (.0-.2)				
	V15-V18, V19 (.0-.3, .8, .9)	V15-V18, V19 (.0-.3, .8, .9)				
Pedestrian, other	V01, V02-V04 (.0), V05, V06,	V01, V02-V04 (.0), V05, V06,				
	V09 (.0,.1,.3,.9)	V09 (.0,.1,.3,.9)				

	All injury	Unintentional	Suicide	Homicide	Undetermined	Legal intervention/war
Mechanism						
Other land transport	V20-V28 (.0-.2), V29 (.0-.3)	V20-V28 (.0-.2), V29 (.0-.3)				
	V30-V39 (.0-.3)	V30-V39 (.0-.3)				
	V40-V49 (.0-.3)	V40-V49 (.0-.3)				
	V50-V59 (.0-.3)	V50-V59 (.0-.3)				
	V60-V69 (.0-.3)	V60-V69 (.0-.3)				
	V70-V79 (.0-.3)	V70-V79 (.0-.3)				
	V80 (.0-.2, .6-.9)	V80 (.0-.2, .6-.9)				
	V81-V82 (.0,.2-.9)	V81-V82 (.0,.2-.9)				
	V83-V86 (.4-.9)	V83-V86 (.4-.9)				
	V87.9	V87.9				
	V88 (.0-.9)	V88 (.0-.9)				
	V89 (.0, .1 .3, .9), X82, Y03, Y32	V89 (.0, .1 .3, .9)	X82	Y03	Y32	
Other Transport	V90-V99, Y36.1,***U01.1**	V90-V99		***U01.1**		Y36.1
Natural /environmental	W42, W43, W53-W64	W42, W43, W53-W64				
	W92-W99, X20-X39, X51-X57	W92-W99, X20-X39, X51-X57				
Overexertion	X50	X50				
Poisoning	X40-X49, X60-X69, X85-X90, Y10-Y19, Y35.2,***U01(.6-.7)**	X40-X49	X60-X69	X85-X90,***U01.6-.7**	Y10-Y19	Y35.2
Struck by or against	W20-W22, W50-W52, X79, Y00, Y04, Y29, Y35.3	W20-W22, W50-W52	X79	Y00, Y04	Y29	Y35.3
Suffocation	W75-W84, X70, X91, Y20	W75-W84	X70	X91	Y20	
Other specified, classifiable	W23, W35-W41, W44, W49, W85-W91,Y85,	W23, W35-W41, W44	X75, X81, ***U03.0**	X96, Y02, Y05-Y07,	Y25, Y31	Y35(.1, .5) Y36(.0, .2,.4-.8)
	X75, X81, X96, Y02, Y05-Y07, Y25, Y31,	W49 W85-W91, Y85		***U01.0, .2, .5**		
	Y35(.1,.5), Y36(.0,.2,.4-.8), ***U01.0, .2, .5, *U03.0**					
Other specified, nec	X58, Y86, X83, Y87.0, Y08, Y87.1, Y33, Y87.2,	X58, Y86	X83, Y87.0	Y08, Y87.1, ***U01.8, *U02**	Y33, Y87.2	Y35.6, Y89 (.0, .1)
	Y35.6, Y89(.0,.1), ***U01.8, *U02**					
Unspecified	X59, X84, Y09, Y34, Y89.9, Y35.7, Y36.9, ***U01.9, *U03.9**	X59	X84, ***U03.9**	Y09, ***U01.9**	Y34, Y89.9	Y35.7 Y36.9
———————————						
Adverse effects	Y40-Y59, Y60-Y84, Y88					
Drugs	Y40-Y59, Y88.0					
Medical care	Y60-Y84, Y88(.1-.3)					

Notes: This framework was developed to be consistent with the framework developed based on ICD-9 external
cause of injury codes as published in http://www.cdc.gov/mmwr/PDF/rr/rr4614.pdf
Drowning is the one external cause that has been redefined in this matrix. Codes for water transportation-related drowning, V90 and V92, are
included in the transportation codes rather than with the drowning codes. In the ICD-9 version of the matrix, the
comparable codes, E830 and E832, were included with drowning. This change was made to be consistent with other mechanisms involved with water transport-related injuries.
In this version, V81.1 and V81.2 were moved from the row for motor vehicle traffic- occupant to the row for motor vehicle traffic- other.
This version also contains the new ICD-10 codes for terrorism. The codes are bolded and are preceded with "*". See http://www.cdc.gov/nchs/about/otheract/icd9/terrorism_code.htm

	All injury	Unintentional	Suicide	Homicide	Undetermined	Legal intervention/war
Mechanism						
ICD-10 Transportation codes						
All Motor Vehicle Accidents combine motor vehicle traffic and non-traffic.						
Motor Vehicle accident codes are equivalent to codes in the NCHS 113 Cause of death list.						
Motor vehicle accidents						
Motor Vehicle Traffic						
Occupant	V30-39 (.4-.9)					
Occupant	V40 "					
Occupant	V50 "					
Occupant	V60 "					
Occupant	V70 "					
Occupant	V83-V86 (.0-.3)					
Motorcyclist	V20-V28 (.3-.9), V29 (.4-.9)					
Pedal cyclist	V12-V14 (.3-.9), V19 (.4-.6)					
Pedestrian	V02-V04 (.1, .9), V09.2					
Other	V80 (.3-.5), V81.1, V82.1					
Unspecified	V87(.0-.8), V89.2					
Motor Vehicle non-Traffic						
Pedestrian, mv-nt	V09.0, V02-V04 (.0)					
Pedal cyclist, mv- nt	V12-V14 (.0-.2), V19 (.0-.2)					
Other mv-nt	V20-V28 (.0-.2), V29 (.0-.3)					
	V30-V39 (.0-.3)					
	V40-V49 (.0-.3)					
	V50-V59 (.0-.3)					
	V60-V69 (.0-.3)					
	V70-V79 (.0-.3)					
	V81.0, V82.0					
	V83-V86 (.4-.9)					
	V88 (.0-.8)					
	V89.0					
Other land transport						
Pedestrian, non-motor vehicle	V01, V05, V06, V09 (.1,.3,.9)					
Pedal cyclist, non-motor vehicle	V10, V11, V15-V18, V19 (.3,.8,.9)					
Animal rider or occupant of animal drawn vehicle	V80(.0-.2, .6-.9)					
Occupant of railway train or railway vehicle	V81 (.2-.9)					
Occupant of streetcar	V82 (.2-.9)					
Other and unspecified	V87-V88 (.9), V89 (.1,.3,.9), X82, Y03, Y32					
Other Transport						
Accident to or on watercraft (other than drowning)	V91, V93					
Transport-related drowning	V90, V92					
Other & unspecified water transport accidents	V94					
Air and space transport accidents	V95-V97					
Other and unspecified transport accidents	V98-V99, Y36.1, ***U01.1**					

APPENDIX 3 TABLES OF HADDON'S ELEMENTS TEXT DESCRIPTORS (STUDY 1)

MECHANISM	HOST TEXT DESCRIPTOR
Cut/Pierce	Intentional self-harm Assault Skin
Drowning	Intentional self-harm Assault
Fall	Intentional self-harm Assault
Fire/hot object or substance	Intentional self-harm Assault
Firearm	Intentional self-harm Assault
Machinery	-------
All Transport	Intentional self-harm Animal rider Animal-rider or occupant of animal drawn vehicle Any occupant (bus) Assault Driver (bus) Driver (car) Driver (four-wheeled special all-terrain or other off-road motor vehicle) Driver (heavy transport vehicle) Driver (motorcycle rider) Driver (occupant) Driver (pedal cyclist) Driver (pick-up truck or van) Driver (special agricultural vehicle) Driver (special all-terrain or other off-road motor vehicle, unspecified number of wheels) Driver (special construction vehicle) Driver (special industrial vehicle) Driver (three-wheeled special all-terrain or other off-road motor vehicle) Driver (two-wheeled special all-terrain or other off-road motor vehicle) Motorcycle rider Occupant (aircraft) Occupant (balloon) Occupant (bus) Occupant (commercial fixed-wing aircraft) Occupant (glider (non-powered)) Occupant (hang-glider) Occupant (heavy transport vehicle) Occupant (helicopter) Occupant (other aircraft) Occupant (other non-powered-aircraft) Occupant (other private fixed-wing aircraft)

MECHANISM	HOST TEXT DESCRIPTOR
	Occupant (pick-up truck or van) Occupant (railway train or railway vehicle) Occupant (spacecraft) Occupant (special industrial vehicle) Occupant (streetcar) Occupant (ultralight, microlight or powered-glider) Occupant (unspecified aircraft) Occupant (unspecified non-powered-aircraft) Other rider or occupant of animal drawn vehicle Parachutist Passenger (bus) Passenger (car) Passenger (four-wheeled special all-terrain or other off-road motor vehicle) Passenger (heavy transport vehicle) Passenger (motorcycle rider) Passenger (occupant) Passenger (pedal cyclist) Passenger (pick-up truck or van) Passenger (special agricultural vehicle) Passenger (special all-terrain or other off-road motor vehicle, unspecified number of wheels) Passenger (special construction vehicle) Passenger (special industrial vehicle) Passenger (three-wheeled special all-terrain or other off-road motor vehicle) Passenger (two-wheeled special all-terrain or other off-road motor vehicle) Pedal cyclist Pedal cyclist (passenger) Pedestrian Person (all-terrain or other off-road motor vehicle) Person (on ground) Person (special agricultural vehicle) Person (special construction vehicle) Person (special industrial vehicle) Person (unknown mode of transport) Person on outside of car Person on outside of vehicle (bus) Person on outside of vehicle (four-wheeled special all-terrain or other off-road motor vehicle) Person on outside of vehicle (heavy transport vehicle) Person on outside of vehicle (occupant) Person on outside of vehicle (pick-up truck or van) Person on outside of vehicle (special all-terrain or other off-road motor

MECHANISM	HOST TEXT DESCRIPTOR
	vehicle, unspecified number of wheels) Person on outside of vehicle (three-wheeled special all-terrain or other off-road motor vehicle) Person on outside of vehicle (two-wheeled special all-terrain or other off-road motor vehicle) Person outside (special agricultural vehicle) Person outside (special construction vehicle) Person outside (special industrial vehicle) Unspecified occupant (four-wheeled special all-terrain or other off-road motor vehicle) Unspecified occupant (special all-terrain or other off-road motor vehicle, unspecified number of wheels) Unspecified occupant (three-wheeled special all-terrain or other off-road motor vehicle) Unspecified occupant (two-wheeled special all-terrain or other off-road motor vehicle)
Natural/Environmental	-------
Overexertion	-------
Poisoning	Intentional self-harm Assault
Struck by or against	Intentional self-harm Assault
Suffocation	Intentional self-harm Assault
Other specified, classifiable	Intentional self-harm Assault Eye or natural orifice
Other specified, nec	Intentional self-harm Assault
Unspecified	Intentional self-harm Assault

MECHANISM	AGENT TEXT DESCRIPTOR Energy	Vehicle/Object	Vector/Perpetrator
Cut/Pierce	Kinetic (contact with)	Foreign body	Acquaintance or friend
	Kinetic (piercing)	Glass	Carer
		Hypodermic needle	Multiple persons unknown to the victim
		Hypodermic needle and syringe	Official authorities
		Knife	Other family member
		Knife, sword or dagger	Parent
		Non-powered hand tool	Person unknown to the victim
		Other powered hand tools and household machinery Powered lawnmower Razor blade Sharp glass	Spouse or domestic partner
Drowning	Deprivation (drowning and submersion)	Bath-tub	Acquaintance or friend
	Kinetic (fall)	Indoor spa, jacuzzi and hot tub	Carer
		Into bath-tub	Multiple persons unknown to the victim
		Into indoor spa, jacuzzi and hot tub	Official authorities
		Into natural water	Other family member
		Into outdoor spa, jacuzzi and hot tub	Parent
		Into swimming pool	Person unknown to the victim
		Natural water Outdoor spa, Jacuzzi and hot tub Swimming pool	Spouse or domestic partner

MECHANISM	AGENT TEXT DESCRIPTOR Energy	Vehicle/Object	Vector/Perpetrator
Falls	Kinetic (diving or jumping)	Another person	Acquaintance or friend
	Kinetic (fall from, out of or through)	Bed	Carer
	Kinetic (fall on and from)	Building or structure	Multiple persons unknown to the victim
	Kinetic (collision with or pushing)	Chair	Official authorities
	Kinetic (slip)	Cliff	Other family member
	Kinetic (stumble)	Flying fox	Parent
	Kinetic (trip)	Ice-skates	Person unknown to the victim
	Kinetic (fall) Kinetic (jumping)	Ladder Other furniture	Spouse or domestic partner
	Kinetic (pushing)	Other persons Playground climbing apparatus Playground equipment Roller-skates Scaffolding Seesaw Skateboard Slide Snowboard Snow ski Stairs and steps Swing Trampoline Tree Treehouse Waterski Wheelchair	Spouse or domestic partner
Fire / hot object or substance	Thermal	Air and gases	Acquaintance or friend
	Thermal (contact with heat and hot substances	Contained tap water	Carer
	Thermal (contact with steam and hot	Drink	Multiple persons unknown to the

MECHANISM	AGENT TEXT DESCRIPTOR Energy	Vehicle/Object	Vector/Perpetrator
	vapours		victim
	Thermal (exposure to	Engines, machinery and tools	Official authorities
	Deprivation (inhalation)	Fat and cooking oil	Other family member
		Fire (controlled)	Parent
		Fire (uncontrolled)	Person unknown to the victim
		Food Heating appliances, radiators and pipes Highly flammable material Household appliances Motor vehicle radiator Nightwear Other clothing and apparel Other fluids Other hot meals Other specified tap water Running tap water Smoke, fire and flames Steam, hot vapours and hot objects Unspecified tap water	Spouse or domestic partner

MECHANISM	**AGENT TEXT DESCRIPTOR** **Energy**	**Vehicle/Object**	**Vector/Perpetrator**
Firearm	Kinetic (discharge)	Air rifle	Acquaintance or friend
		Firearm	Carer
		Handgun	Multiple persons unknown to the victim
		Large calibre rifle	Official authorities
		Other and unspecified firearms	Other family member
		Shotgun	Parent
		Small calibre rifle	Person unknown t the victim; spouse or domestic partner
Machinery	Kinetic (contact with)	Agricultural machinery Earthmoving, scraping and other excavating machinery Fertiliser spreader Grain auger, elevator and conveyor Harvesting machinery Hay baler and haying implements Lifting and transmission devices Machinery Metalworking machinery Mining and earth drilling machinery Posthole digger Prime mover Seeding and planting implement Slasher Tillage and cultivating	

MECHANISM	**AGENT TEXT DESCRIPTOR**		
	Energy	**Vehicle/Object**	**Vector/Perpetrator**
		equipment Unspecified equipment towed or powered by tractor Woodworking and farming machinery	
All Transport	Deprivation (drowning and submersion)	Motor vehicles	
	Kinetic (collision between)	Agricultural vehicle	
	Kinetic (collision with)	Aircraft	
	Kinetic (crashing)	All-terrain four-wheel drive	
	Kinetic (fall from or being thrown from)	All-terrain or other off-road motor vehicle	
	Kinetic (fall from)	Animal	
	Kinetic (fall in)	Animal or animal drawn vehicle	
	Kinetic (in derailment without antecedent collision)	Balloon Bus Car Canoe or kayak Car Car with fixed or stationary object Car with other motor vehicle Car, pick-up truck or van Commercial fixed-wing aircraft Fishing boat Four-wheeled motorcycle Four-wheeled special all-terrain or other Glider non-powered Hang-glider Heavy transport vehicle	

MECHANISM	AGENT TEXT DESCRIPTOR Energy	Vehicle/Object	Vector/Perpetrator
		Helicopter Horse Inflatable craft Merchant ship Motor vehicle Motor-scooter, moped or motorised bicycle Motorcycle Non-motor vehicle Offroad motorcycle Onroad motorcycle Non-powered aircraft Powered watercraft Private fixed-wing airer Unpowered watercraft Parachute Passenger ship Passenger van Pedal cycle Pickup truck or van Railway train or railway vehicle Sailboat Sedan Spacecraft	

MECHANISM	AGENT TEXT DESCRIPTOR		
	Energy	**Vehicle/Object**	**Vector/Perpetrator**
	Kinetic (in derailment without antecedent collision) cont.	Special all-terrain or other off-road motor vehicle Special construction vehicle Special industrial vehicle Streetcar Three-wheeled motor vehicle Three-wheeled special all-terrain or other Two-wheeled special all-terrain or other Ultralight, microlight or power Watercraft Non-powered aircraft Water transport; fishing boat Water transport; inflatable craft	

MECHANISM	ENVIRONMENT TEXT DESCRIPTOR
Cut/Pierce	------
Drowning	Bath-tub Indoor spa Outdoor spa Jacuzzi Natural water Hot tub Swimming-pool
Fall	High place From one level to another Ice & snow Water Same level While being carried or supported by other persons
Fire/hot object or substance	Building or structure Not in building or structure
Firearm	------
Machinery	------
All Transport	Air transport accident Air transport accident (aircraft) Non-traffic accident On-board watercraft Traffic accident Transport accident While boarding or alighting While boarding or alighting (aircraft) While boarding or alighting (special construction vehicle) While boarding or alighting from streetcar
Natural/Environmental	Weightless environment
Overexertion	------
Poisoning	------
Struck by or against	-------
Suffocation	Bed Low oxygen environment
Other specified, classifiable	-------
Other specified, nec	-------
Unspecified	

APPENDIX 4 DATA COMPLETENESS VS INFORMATION QUALITY BY INTENT AND MECHANISM

HOST		All Intents		Unintentional		Self Harm		Assault		Undetermined	
		Def	Undef	Def	Undef	Def	Undef	Def	Undef	Def	Undef
All Injury	Present	1725	120	1364	13	33	15	328	92	0	0
	Not Present	340	55	292	34	0	0	10	10	38	11
	% Agreement	**79.5%**		**82.1%**		**68.8%**		**76.8%**		**22.4%**	
Cut/Pierce	Present	45	22	1	0	4	2	40	20	0	0
	Not Present	9	2	5	0	0	0	0	0	4	2
	% Agreement	**60.3%**		**16.7%**		**66.7%**		**66.7%**		**33.3%**	
Drowning	Present	33	22	0	0	3	2	30	20	0	0
	Not Present	13	4	10	2	0	0	0	0	3	2
	% Agreement	**51.4%**		**16.7%**		**60.0%**		**60.0%**		**40.0%**	
Fall	Present	11	0	0	0	1	0	10	0	0	0
	Not Present	33	3	32	3	0	0	0	0	1	0
	% Agreement	**29.8%**		**8.6%**		**100.0%**		**100.0%**		**0.0%**	
Fire/hot object or substance	Present	22	0	0	0	2	0	20	0	0	0
	Not Present	26	3	24	3	0	0	0	0	2	0
	% Agreement	**49.0%**		**11.1%**		**100.0%**		**100.0%**		**0.0%**	
Firearm	Present	55	11	0	0	5	1	50	10	0	0
	Not Present	12	1	6	0	0	0	0	0	6	1
	% Agreement	**70.9%**		**0.0%**		**83.3%**		**83.3%**		**14.3%**	
Machinery	Present	0	0	0	0						
	Not Present	20	0	20	0						
	% Agreement	**0.0%**		**0.0%**							
All Transport	Present	1444	19	1362	13	4	4	78	2	0	0
	Not Present	86	10	78	10	0	0	0	0	8	0
	% Agreement	**93.3%**		**93.8%**		**50.0%**		**97.5%**		**0.0%**	
Natural / Environmental	Present	0	0	0	0						
	Not Present	73	7	73	7						
	% Agreement	**8.8%**		**8.8%**							
Overexertion	Present	0	0	0	0						
	Not Present	1	0	1	0						
	% Agreement	**0.0%**		**0.0%**							
Poisoning	Present	50	24	0	0	10	4	40	20	0	0
	Not Present	20	8	10	4	0	0	0	0	10	4
	% Agreement	**56.9%**		**28.6%**		**71.4%**		**66.7%**		**28.6%**	
Struck by or against	Present	21	0	0	0	1	0	20	0	0	0
	Not Present	11	0	10	0	0	0	0	0	1	
	% Agreement	**65.6%**		**0.0%**		**100.0%**		**100.0%**		**0.0%**	
Suffocation	Present	11	0	0	0	1	0	10	0	0	0
	Not Present	8	2	7	2	0	0	0	0	1	0
	% Agreement	**61.9%**		**22.2%**		**100.0%**		**100.0%**		**0.0%**	
Other Specified, Classifiable	Present	32	0	1	0	2	0	29	0	0	0
	Not Present	28	11	16	1	0	0	10	10	2	0
	% Agreement	**60.6%**		**11.1%**		**100.0%**		**79.6%**		**0.0%**	
Other Specified, nec	Present	1	11	0	0	0	1	1	10	0	0
	Not Present	0	2	0	1	0	0	0	0	0	1
	% Agreement	**21.4%**		**100.0%**		**0.0%**		**9.1%**		**100.0%**	
UnSpecified	Present	0	11	0	0	0	1	0	10	0	0
	Not Present	0	2	0	1	0	0	0	0	0	1
	% Agreement	**15.4%**		**100.0%**		**0.0%**		**0.0%**		**100.0%**	

AGENT		All Intents		Unintentional		Self Harm		Assault		Undetermined	
		Def	Undef	Def	Undef	Def	Undef	Def	Undef	Def	Undef
All Injury	Present	2061	156	1652	42	33	11	338	94	38	9
	Not Present	4	19	4	5	0	4	0	8	0	2
	%Agreement	**92.9%**		**97.3%**		**77.1%**		**78.6%**		**81.6%**	
Cut/Pierce	Present	54	18	6	0	4	0	40	16	4	2
	Not Present	0	6	0	0	0	2	0	4	0	0
	%Agreement	**76.9%**		**100.0%**		**100.0%**		**73.3%**		**66.7%**	
Drowning	Present	46	26	10	2	3	2	30	20	3	2
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**63.9%**		**83.3%**		**60.0%**		**60.0%**		**60.0%**	
Fall	Present	44	3	32	3	1	0	10	0	1	0
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**93.6%**		**91.4%**		**100.0%**		**100.0%**		**100.0%**	
Fire/hot object or substance	Present	48	3	24	3	2	0	20	0	2	0
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**94.1%**		**88.9%**		**100.0%**		**100.0%**		**100.0%**	
Firearm	Present	67	12	6	0	5	1	50	10	6	1
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**84.8%**		**100.0%**		**83.3%**		**83.3%**		**85.7%**	
Machinery	Present	20	0	20	0						
	Not Present	0	0	0	0						
	%Agreement	**100.0%**		**100.0%**							
All Transport	Present	1526	26	1436	20	4	4	78	2	8	0
	Not Present	4	3	4	3	0	0	0	0	0	0
	%Agreement	**98.1%**		**98.4%**		**50.0%**		**97.5%**		**100.0%**	
Natural/Environmental	Present	73	7	73	7						
	Not Present	0	0	0	0						
	%Agreement	**91.3%**		**91.3%**							
Overexertion	Present	1	0	1	0						
	Not Present	0	0	0	0						
	%Agreement	**100.0%**		**100.0%**							
Poisoning	Present	70	32	10	4	10	4	40	20	10	4
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**68.6%**		**71.4%**		**71.4%**		**66.7%**		**71.4%**	
Struck by or against	Present	32	0	10	0	1	0	20	0	1	0
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**	
Suffocation	Present	19	2	7	2	1	0	10	0	1	0
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**90.5%**		**77.8%**		**100.0%**		**100.0%**		**100.0%**	
Other Specified, Classifiable	Present	60	11	17	1	2	0	39	10	2	0
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**84.5%**		**94.4%**		**100.0%**		**79.6%**		**100.0%**	
Other Specified, nec	Present	1	8	0	0	0	0	1	8	0	0
	Not Present	0	5	0	1	0	1	0	2	0	1
	%Agreement	**42.9%**		**100.0%**		**100.0%**		**27.3%**		**100.0%**	
UnSpecified	Present	0	8	0	0	0	0	0	8	0	0
	Not Present	0	5	0	1	0	1	0	2	0	1
	%Agreement	**38.5%**		**100.0%**		**100.0%**		**20.0%**		**100.0%**	

ENERGY		All Intents		Unintentional		Self Harm		Assault		Undetermined	
		Def	Undef	Def	Undef	Def	Undef	Def	Undef	Def	Undef
All Injury	Present	1722	112	1378	30	28	11	278	62	38	9
	Not Present	343	63	278	17	5	4	60	40	0	2
	%Agreement	**79.7%**		**81.9%**		**66.7%**		**72.3%**		**81.6%**	
Cut/Pierce	Present	10	2	6	0	0	0	0	0	4	2
	Not Present	44	22	0	0	4	2	40	20	0	0
	%Agreement	**41.0%**		**100.0%**		**33.3%**		**33.3%**		**66.7%**	
Drowning	Present	46	26	10	2	3	2	30	20	3	2
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**63.9%**		**83.3%**		**60.0%**		**60.0%**		**60.0%**	
Fall	Present	44	3	32	3	1	0	10	0	1	0
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**93.6%**		**91.4%**		**100.0%**		**100.0%**		**100.0%**	
Fire/hot object or substance	Present	48	3	24	3	2	0	20	0	2	0
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**94.1%**		**88.9%**		**100.0%**		**100.0%**		**100.0%**	
Firearm	Present	67	12	6		5	1	50	10	6	1
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**84.8%**		**100.0%**		**83.3%**		**83.3%**		**85.7%**	
Machinery	Present	20	0	20	0						
	Not Present	0	0	0	0						
	%Agreement	**100.0%**		**100.0%**							
Natural/Environmental	Present	67	6	67	6						
	Not Present	6	1	6	1						
	%Agreement	**85.0%**		**85.0%**							
Overexertion	Present	1	0	1	0						
	Not Present	0	0	0	0						
	%Agreement	**100.0%**		**100.0%**							
All Transport	Present	1258	15	1168	9	4	4	78	2	8	0
	Not Present	272	14	272	14	0	0	0	0	0	0
	%Agreement	**81.6%**		**80.8%**		**50.0%**		**97.5%**		**100.0%**	
Poisoning	Present	70	32	10	4	10	4	40	20	10	4
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**68.6%**		**71.4%**		**71.4%**		**66.7%**		**71.4%**	
Struck by or against	Present	11	0	10	0	0	0	0	0	1	0
	Not Present	21	0	0	0	1	0	20	0	0	0
	%Agreement	**34.4%**		**100.0%**		**0.0%**		**0.0%**		**100.0%**	
Suffocation	Present	19	2	7	2	1	0	10	0	1	0
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**90.5%**		**77.8%**		**100.0%**		**100.0%**		**100.0%**	
Other Specified, Classifiable	Present	60	11	17	1	2	0	39	10	2	0
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**84.5%**		**94.4%**		**100.0%**		**79.6%**		**100.0%**	
Other Specified, nec	Present	1	0	0	0	0	0	1	0	0	1
	Not Present	0	13	0	1	0	1	0	10	0	0
	%Agreement	**100.0%**		**100.0%**		**100.0%**		**100.0%**		**0.0%**	
UnSpecified	Present	0	0	0	0	0	0	0	0	0	1
	Not Present	0	13	0	1	0	1	0	10	0	0
	%Agreement	**100.0%**		**100.0%**		**100.0%**		**100.0%**		**0.0%**	

VECTOR/OBJECT		All Intents		Unintentional		Self Harm		Assault		Undetermined	
		Def	Undef	Def	Undef	Def	Undef	Def	Undef	Def	Undef
All Injury	Present	1929	71	1564	25	31	9	298	32	36	5
	Not Present	62	97	18	15	2	6	40	70	2	6
	%Agreement	**93.8%**		**97.3%**		**77.1%**		**83.6%**		**85.7%**	
Cut/Pierce	Present	54	0	6	0	4	0	40	0	4	0
	Not Present	0	24	0	0	0	2	0	20	0	2
	%Agreement	**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**	
Drowning	Present	46	0	10	0	3	0	30	0	3	0
	Not Present	0	26	0	2	0	2	0	20	0	2
	%Agreement	**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**	
Fall	Present	27	0	27	0	0	0	0	0	0	0
	Not Present	17	3	5	3	1	0	10	0	1	0
	%Agreement	**63.8%**		**85.7%**		**0.0%**		**0.0%**		**0.0%**	
Fire/hot object or substance	Present	46	0	22	0	2	0	20	0	2	0
	Not Present	2	3	2	3	0	0	0	0	0	0
	%Agreement	**96.1%**		**92.6%**		**100.0%**		**100.0%**		**100.0%**	
Firearm	Present	67	12	6	0	5	1	50	10	6	1
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**84.8%**		**100.0%**		**83.3%**		**83.3%**		**85.7%**	
Machinery	Present	20	0	20	0						
	Not Present	0	0	0	0						
	%Agreement	**100.0%**		**100.0%**							
All Transport	Present	1526	26	1436	20	4	4	78	2	8	0
	Not Present	4	3	4	3	0	0	0	0	0	0
	%Agreement	**98.1%**		**98.4%**		**50.0%**		**97.5%**		**100.0%**	
Natural/Environmental	Present										
	Not Present										
	%Agreement										
Overexertion	Present										
	Not Present										
	%Agreement										
Poisoning	Present	70	32	10	4	10	4	40	20	10	4
	Not Present	0	0	0	0	0	0	0	0	0	0
	%Agreement	**68.6%**		**71.4%**		**71.4%**		**66.7%**		**71.4%**	
Struck by or against	Present	31	0	9	0	1	0	20	0	1	0
	Not Present	1	0	1	0	0	0	0	0	0	0
	%Agreement	**96.9%**		**90.0%**		**100.0%**		**100.0%**		**100.0%**	
Suffocation	Present	3	0	3	0	0	0	0	0	0	0
	Not Present	16	2	4	2	1	0	10	0	1	0
	%Agreement	**23.8%**		**55.6%**		**0.0%**		**0.0%**		**0.0%**	
Other Specified, Classifiable	Present	38	1	15	1	2	0	19	0	2	0
	Not Present	22	10	2	0	0	0	20	10	0	0
	%Agreement	**67.6%**		**83.3%**		**100.0%**		**59.2%**		**100.0%**	
Other Specified, nec	Present	1	0	0	0	0	0	1	0	0	0
	Not Present	0	13	0	1	0	1	0	10	0	1
	%Agreement	**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**	
UnSpecified	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	0	13	0	1	0	1	0	10	0	1
	%Agreement	**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**	

VEHICLE/PERP		All Intents		Unintentional		Self Harm		Assault		Undetermined	
		Def	Undef	Def	Undef	Def	Undef	Def	Undef	Def	Undef
All Injury	Present	1476	100	1194	14	4	4	270	82	8	0
	Not Present	111	24	43	4	0	0	68	20	0	0
	%Agreement	**87.7%**		**95.5%**		**50.0%**		**65.9%**		**100.0%**	
Cut/Pierce	Present	32	16					32	16		
	Not Present	8	4					8	4		
	%Agreement	**60.0%**						**60.0%**			
Drowning	Present	24	16					24	16		
	Not Present	6	4					6	4		
	%Agreement	**56.0%**						**56.0%**			
Fall	Present	8	0					8	0		
	Not Present	2	0					2	0		
	%Agreement	**80.0%**						**80.0%**			
Fire/hot object or substance	Present	16	0					16	0		
	Not Present	4	0					4	0		
	%Agreement	**80.0%**						**80.0%**			
Firearm	Present	40	8					40	8		
	Not Present	10	2					10	2		
	%Agreement	**70.0%**						**70.0%**			
Machinery	Present										
	Not Present										
	%Agreement										
All Transport	Present	1195	15	1121	9	4	4	62	2	8	0
	Not Present	58	0	42	0	0	0	16	0	0	0
	%Agreement	**94.2%**		**95.6%**		**50.0%**		**77.5%**		**100.0%**	
Natural/Environmental	Present	72	5	72	5						
	Not Present	1	2	1	2						
	%Agreement	**92.5%**		**92.5%**							
Overexertion	Present	1	0	1	0						
	Not Present	0	0	0	0						
	%Agreement	**100.0%**		**100.0%**							
Poisoning	Present	32	16					32	16		
	Not Present	8	4					8	4		
	%Agreement	**60.0%**						**60.0%**			
Struck by or against	Present	16	0					16	0		
	Not Present	4	0					4	0		
	%Agreement	**80.0%**						**80.0%**			
Suffocation	Present	8	0	0	0			8	0		
	Not Present	2	2	0	2			2	0		
	%Agreement	**83.3%**		**100.0%**				**80.0%**			
Other Specified, Classifiable	Present	31	8					31	8		
	Not Present	8	2					8	2		
	%Agreement	**67.3%**						**67.3%**			
Other Specified, nec	Present	1	8					1	8		
	Not Present	0	2					0	2		
	%Agreement	**27.3%**						**27.3%**			
UnSpecified	Present	0	8					0	8		
	Not Present	0	2					0	2		
	%Agreement	**20.0%**						**20.0%**			

ENVIRONMENT		All Intents		Unintentional		Self Harm		Assault		Undetermined	
		Def	Undef	Def	Undef	Def	Undef	Def	Undef	Def	Undef
All Injury	Present	1494	23	1357	17	7	4	118	2	12	0
	Not Present	571	152	299	30	26	11	220	100	26	11
	%Agreement	**73.5%**		**81.4%**		**37.5%**		**49.5%**		**46.9%**	
Cut/Pierce	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	54	24	6	0	4	2	40	20	4	2
	%Agreement	**30.8%**		**0.0%**		**33.3%**		**33.3%**		**33.3%**	
Drowning	Present	46	0	10	0	3	0	30	0	3	0
	Not Present	0	26	0	2	0	2	0	20	0	2
	%Agreement	**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**	
Fall	Present	18	2	7	2	0	0	10	0	1	0
	Not Present	26	1	25	1	1	0	0	0	0	0
	%Agreement	**40.4%**		**22.9%**		**0.0%**		**100.0%**		**100.0%**	
Fire/hot object or substance	Present	4	0	4	0	0	0	0	0	0	0
	Not Present	44	3	20	3	2	0	20	0	2	0
	%Agreement	**13.7%**		**25.9%**		**0.0%**		**0.0%**		**0.0%**	
Firearm	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	67	12	6	0	5	1	50	10	6	1
	%Agreement	**15.2%**		**0.0%**		**16.7%**		**16.7%**		**14.3%**	
Machinery	Present	0	0	0	0						
	Not Present	20	0	20	0						
	%Agreement	**0.0%**		**0.0%**							
All Transport	Present	1423	21	1333	15	4	4	78	2	8	0
	Not Present	107	8	107	8	0	0	0	0	0	0
	%Agreement	**91.8%**		**91.7%**		**50.0%**		**97.5%**		**100.0%**	
Natural/Environmental	Present	1	0	1	0						
	Not Present	72	7	72	7						
	%Agreement	**10.0%**		**10.0%**							
Overexertion	Present	0	0	0	0						
	Not Present	1	0	1	0						
	%Agreement	**0.0%**		**0.0%**							
Poisoning	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	70	32	10	4	10	4	40	20	10	4
	%Agreement	**31.4%**		**28.6%**		**28.6%**		**33.3%**		**28.6%**	
Struck by or against	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	32	0	10	0	1	0	20	0	1	0
	%Agreement	**0.0%**		**0.0%**		**0.0%**		**0.0%**		**0.0%**	
Suffocation	Present	2	0	2	0	0	0	0	0	0	0
	Not Present	17	2	5	2	1	0	10	0	1	0
	%Agreement	**19.0%**		**44.4%**		**0.0%**		**0.0%**		**0.0%**	
Other Specified, Classifiable	Present	0	0	0	0	2	0	0	0	0	0
	Not Present	60	11	17	1	0	0	39	10	2	0
	%Agreement	**15.5%**		**5.6%**		**100.0%**		**20.4%**		**0.0%**	
Other Specified, nec	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	1	13	0	1	0	1	1	10	0	1
	%Agreement	**92.9%**		**100.0%**		**100.0%**		**90.9%**		**100.0%**	
UnSpecified	Present	0	0	0	0	0	0	0	0	0	0
	Not Present	0	13	0	1	0	1	0	10	0	1
	%Agreement	**100.0%**		**100.0%**		**100.0%**		**100.0%**		**100.0%**	

APPENDIX 4 RELATIVE UTILISATION TABLES: LOW RATE AND UNDERUTILISED POOR QUALITY CODES

Proportional Utilisation of Non-Priority Code Blocks

		QHAPDC Rate	ICD Rate	Rate Ratio	Confidence Interval (Lower)	Confidence Interval (Upper)
ALL						
Host	Struck by or against	0.58	0.34	1.68	0.93	3.03
	Suffocation	0.59	0.48	1.25	0.67	2.33
Vector/Object	Fall	0.65	0.43	1.54	0.99	2.38
	Fire/hot object or substance	0.18	0.10	1.86	0.77	4.47
	Struck by or against	0.15	0.03	4.74	0.67	33.68
Vehicle/Perp	All Injury	0.06	0.06	1.08	0.91	1.27
	Drowning	0.00	0.14	0.00	0.00	0.00
	Natural/Environmental	0.02	0.04	0.47	0.15	1.49
	Struck by or against	0.18	0.13	1.44	0.54	3.84
	Other Specified, nec	0.05	0.14	0.38	0.09	1.55
	Unspecified	0.06	0.15	0.38	0.10	1.53
UNINTENTIONAL						
Environment	Drowning	0.17	0.17	1.05	0.26	4.26
Energy	All Injury	0.19	0.17	1.12	1.00	1.25
Vector/Object	Fire/hot object or substance	0.19	0.19	1.01	0.42	2.44
	Struck by or against	0.26	0.10	2.57	0.36	18.26
Vehicle/Perp	Natural/Environmental	0.02	0.04	0.47	0.15	1.49
SELF HARM						
Agent	All Injury	0.03	0.08	0.39	0.15	1.04
	Cut/Pierce	0.19	0.33	0.58	0.15	2.35
Environment	Drowning	0.67	0.40	1.67	0.23	11.83
Energy	All Injury	0.13	0.19	0.67	0.35	1.29
Vector/Object	Cut/Pierce	0.19	0.33	0.58	0.15	2.35
	Drowning	1.00	0.40	2.50	0.42	14.96
ASSAULT						
Agent	Cut/Pierce	0.10	0.07	1.43	0.53	3.87
	Other Specified, nec	0.35	0.18	1.91	0.47	7.82
	Unspecified	0.59	0.20	2.93	0.73	11.74
Vector/Object	All Injury	0.22	0.25	0.89	0.73	1.07
	Drowning	1.00	0.40	2.50	0.58	10.70
Vehicle/Perp	Drowning	0.00	0.20	0.00	0.00	0.00
	Fall	0.52	0.20	2.58	0.59	11.22
	Fire/hot object or substance	0.19	0.20	0.95	0.29	3.16
	Firearm	0.28	0.20	1.42	0.68	2.97
	All Transport	0.00	0.20	0.00	0.00	0.00
	Poisoning	0.20	0.20	0.98	0.42	2.27
	Struck by or against	0.43	0.20	2.14	0.80	5.69
	Suffocation	0.17	0.20	0.83	0.15	4.55
	Other Specified, Classifiable	0.25	0.20	1.23	0.65	2.33
	Other Specified, nec	0.35	0.18	1.91	0.47	7.82
	Unspecified	0.59	0.20	2.93	0.73	11.74
UNDETERMINED						
Environment	Drowning	0.50	0.40	1.25	0.18	8.87
Energy	All Injury	0.07	0.04	1.76	0.43	7.17
Vector/Object	All Injury	0.16	0.16	0.99	0.49	2.01
	Cut/Pierce	0.17	0.33	0.50	0.11	2.14
	Drowning	1.00	0.40	2.50	0.46	13.65

Zero & Underutilised 'Haddon's Element Absent' codes

		QHAPDC Rate	ICD Rate	Rate Ratio	Confidence Interval (Lower)	Confidence Interval (Upper)
ALL						
Host	All Transport	0.05	0.06	0.76	0.62	0.93
Agent	Drowning	0.00	0.00	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	Machinery	0.00	0.00	0.00	0.00	0.00
	Natural/Environmental	0.00	0.00	0.00	0.00	0.00
	Overexertion	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.00	0.00	0.00	0.00	0.00
	Suffocation	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.00	0.00	0.00	0.00	0.00
Environment	Drowning	0.18	0.36	0.50	0.32	0.77
Energy	Drowning	0.00	0.00	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	Machinery	0.00	0.00	0.00	0.00	0.00
	Natural/Environmental	0.01	0.09	0.06	0.03	0.13
	Overexertion	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.42	0.66	0.64	0.42	0.99
	Suffocation	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.00	0.00	0.00	0.00	0.00
Vector/Object	Cut/Pierce	0.03	0.31	0.09	0.06	0.14
	Firearm	0.00	0.00	0.00	0.00	0.00
	Machinery	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.08	0.45	0.18	0.12	0.25
Vehicle/Perp	Cut/Pierce	0.02	0.15	0.16	0.09	0.29
	Fall	0.00	0.04	0.01	0.00	0.02
	Fire/hot object or substance	0.00	0.08	0.02	0.01	0.08
	Firearm	0.06	0.15	0.42	0.20	0.87
	Machinery	0.00	0.00	0.00	0.00	0.00
	Overexertion	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.12	0.00	0.00	0.01
	Suffocation	0.02	0.19	0.10	0.03	0.30
	Other Specified, Classifiable	0.01	0.14	0.10	0.05	0.18

		QHAPDC Rate	ICD Rate	Rate Ratio	Confidence Interval (Lower)	Confidence Interval (Upper)
UNINTENTIONAL						
Host	All Transport	0.05	0.06	0.78	0.63	0.96
Agent	Cut/Pierce	0.00	0.00	0.00	0.00	0.00
	Drowning	0.00	0.00	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	Machinery	0.00	0.00	0.00	0.00	0.00
	Natural/Environmental	0.00	0.00	0.00	0.00	0.00
	Overexertion	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.00	0.00	0.00	0.00	0.00
	Suffocation	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.00	0.00	0.00	0.00	0.00
Environment	Fall	0.48	0.74	0.64	0.44	0.95
Energy	Cut/Pierce	0.00	0.00	0.00	0.00	0.00
	Drowning	0.00	0.00	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	Machinery	0.00	0.00	0.00	0.00	0.00
	Natural/Environmental	0.01	0.09	0.06	0.03	0.13
	Overexertion	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.00	0.00	0.00	0.00	0.00
	Suffocation	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.00	0.00	0.00	0.00	0.00
Vector/Object	Cut/Pierce	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	Machinery	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.03	0.11	0.26	0.06	1.03
Vehicle/Perp	Overexertion	0.00	0.00	0.00	0.00	0.00
SELF HARM						
Host	All Injury	0.00	0.00	0.00	0.00	0.00
	Cut/Pierce	0.00	0.00	0.00	0.00	0.00
	Drowning	0.00	0.00	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	All Transport	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.00	0.00	0.00	0.00	0.00
	Suffocation	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.00	0.00	0.00	0.00	0.00
	Other Specified, nec	0.00	0.00	0.00	0.00	0.00

		QHAPDC Rate	ICD Rate	Rate Ratio	Confidence Interval (Lower)	Confidence Interval (Upper)
SELF HARM						
Agent	Drowning	0.00	0.00	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	All Transport	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.00	0.00	0.00	0.00	0.00
	Suffocation	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.00	0.00	0.00	0.00	0.00
Environment	All Transport	0.00	0.00	0.00	0.00	0.00
Energy	Drowning	0.00	0.00	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	All Transport	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Suffocation	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.00	0.00	0.00	0.00	0.00
Vector/Object	All Injury	0.06	0.17	0.37	0.19	0.75
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	All Transport	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.00	0.00	0.00	0.00	0.00
Vehicle/Perp	All Injury	0.00	0.00	0.00	0.00	0.00
	All Transport	0.00	0.00	0.00	0.00	0.00
ASSAULT						
Host	All Injury	0.04	0.00	0.00	0.00	0.00
	Cut/Pierce	0.00	0.00	0.00	0.00	0.00
	Drowning	0.00	0.00	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	All Transport	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.00	0.00	0.00	0.00	0.00
	Suffocation	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.82	0.00	0.00	0.00	0.00
	Other Specified, nec	0.00	0.00	0.00	0.00	0.00
	Unspecified	0.00	0.00	0.00	0.00	0.00
Agent	Drowning	0.00	0.00	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	All Transport	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.00	0.00	0.00	0.00	0.00
	Suffocation	0.00	0.00	0.00	0.00	0.00

		QHAPDC Rate	ICD Rate	Rate Ratio	Confidence Interval (Lower)	Confidence Interval (Upper)
ASSAULT						
Environment	Drowning	0.00	0.40	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	All Transport	0.00	0.00	0.00	0.00	0.00
Energy	Drowning	0.00	0.00	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	All Transport	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Suffocation	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.00	0.00	0.00	0.00	0.00
Vector/Object	Cut/Pierce	0.14	0.33	0.43	0.27	0.68
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	All Transport	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.00	0.61	0.00	0.00	0.00
UNDETERMINED						
Agent	Cut/Pierce	0.00	0.00	0.00	0.00	0.00
	Drowning	0.00	0.00	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.00	0.00	0.00	0.00	0.00
	Suffocation	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.00	0.00	0.00	0.00	0.00
Environment	Fall	0.00	0.00	0.00	0.00	0.00
Energy	Cut/Pierce	0.00	0.00	0.00	0.00	0.00
	Drowning	0.00	0.00	0.00	0.00	0.00
	Fall	0.00	0.00	0.00	0.00	0.00
	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.00	0.00	0.00	0.00	0.00
	Suffocation	0.00	0.00	0.00	0.00	0.00
	Other Specified, Classifiable	0.00	0.00	0.00	0.00	0.00
Vector/Object	Fire/hot object or substance	0.00	0.00	0.00	0.00	0.00
	Firearm	0.00	0.00	0.00	0.00	0.00
	Poisoning	0.00	0.00	0.00	0.00	0.00
	Struck by or against	0.00	0.00	0.00	0.00	0.00

APPENDIX 5 MEDICAL RECORD REVIEW – CODER MANUAL

Developing and Enhancing the Quality of National Injury-Related Hospital Morbidity Data

A Guide for Data Collectors

Medical Record Review

Section 1

ICD-10-AM Third Edition External Causes of Injury

Section 2

ICECI Data Collection Guide

Classification of International Classification of External Causes of Injuries (ICECI)

Section 1

ICD-10-AM Third Edition External Causes of Injury

Introduction

The purposes of the project are to:

1. Analyse utilisation patterns of external cause codes in national hospital morbidity data.
2. Obtain detailed information about the quality and completeness of medical records in relation to external cause data in Australian hospitals.
3. Investigate documentation and coding practices in Australian hospitals as it relates to external cause coding which includes reasons for a lack of use/lack of specificity in code usage.
4. Identify how coded external cause data is currently being used by injury researchers and agencies.
5. Identify the extent to which the ICECI can be applied to Australian hospital data.

The project hopes to identify opportunities to:

1. Develop and provide informal and formal education for clinicians, clinical coders, and injury data users relating to the documentation, coding, and analysis of circumstances of injuries.
2. Develop documentation, data collection processes and coding standards which will enhance the collection of external cause information from inpatient medical records thereby:
    i. Improving the efficiency of coding external causes of injuries
    ii. Enhancing the quality of national external cause of injury data.
3. Facilitate classification development by informed decisions on documentation and coding practice.

Data Collection

As an expert coder your services have been retained to facilitate the data collection phase of the project by applying a simplified ACBA (Australian Coding Benchmark Audit) methodology for selected patient episodes of care in target hospitals. You will review the medical record (MR) for each case listed for the target hospital, abstract and code external causes of injury information using ICD-10-AM Third edition and identify the type/s of source documentation. You are required to document ALL text entries from the medical record that relate to the circumstances of the injury whether they can be coded in ICD-10-AM or not.

It will not be necessary to assign ICD-10-AM Third Edition codes to the nature of injuries themselves or to any procedures performed. However, nature of injury and procedural information, where they provide direction or specificity for external cause coding, should be documented. For example positive identification of venom by a Venom Detection Kit or administration of antivenom will determine external cause code assignment – ie: Administration of "Brown snake antivenom" indicates assignment of *X20.00 Contact with brown snake.*

The codes for the nature of injuries have been abstracted from the national morbidity dataset and will be provided on each Data Collection Form for each case. So, rather than a full medical record review, the focus of the expert coder is to identify information relating to the circumstances of injury, place of occurrence of the injury event and the activity of the victim at the time of the injury event.

The International Classification of External Causes of Injury (ICECI) allows for the classification of external causes of injury in far more detail and from a number of different perspectives than the ICD-10-AM. Data collectors should familiarise themselves with the ICECI, see

Section 2, with a view to capturing details relevant to coding both ICECI and ICD-10-AM. Essentially anything indicating objects, mechanisms, safety equipment used or not used, levels of participation in formal training etc.

Data Collection Form

The External Cause Data Quality: Data Collection Form has been designed to capture documented narrative relevant to coding external causes of injury in both ICD-10-AM and ICECI. Common sources of documentation have labelled sections on the form to indicate narrative derived from the: Ambulance Form, Emergency Department Notes, Clinical Progress Notes, Discharge Summary and Others. There is also space for general comments as deemed necessary by the reviewer.

Ambulance Form: Each state has an individual Ambulance form and information that can be collected may vary. Ambulance Call Outs generally contain good detail on circumstances of injury. Indicate a call out by noting the “pick up” address in the narrative. Eg. p/u residence, or p/u outside ‘Named’ supermarket, such information may be useful, in light of or in the absence of other documentation to indicate place of occurrence (POO). Ambulance Transfers generally contain less information on circumstances of injury, but indicate the likely presence of a referral and/or referral notes.

ED Notes: Contain some information about the circumstances of injury that may be taken from the Ambulance form, from the patient or from those accompanying the patient. Indicate the source of this information where documented. Eg. “BIB Mum – states found groggy sitting at base of fence.” “Pt states fell from fence after he caught his jeans on a nail protruding from the fence” “Bystanders stated pt stepped off gutter into path of moving car”

Clinical/Progress notes: Indicate the source of the progress notes and where the relevant entry was preceded or followed by other (irrelevant) narrative. Eg. An entry in the progress notes by nursing staff of: “Nursing: 12 y/o boy admitted to orthopaedic ward post fall from fence with fractured tibia - for ORIF in am.” Should be documented as “Nsg: …post fall from fence …”. The registrar treating the boy may also make an entry that the boy “fell from fence”. Indicate the source and relevant narrative. “ORTHO Reg: … fell from fence…”

Discharge Summary: If a Discharge Summary is not included in the record place a cross through the words “Discharge Summary” on the data Collection Form. If a Discharge Summary is included document all entries relevant to external cause coding. In some cases this may only be the nature of the injury, for example “#s” or “Lacerations”.

Front Sheet: There has been no section dedicated to the Front Sheet on the Data Collection Form. Use the lower part of the “Discharge Summary” section or the “Other” section to record narrative on the Front Sheet.

Other: Use this space to document all other documentation sources, such as referrals, referral notes, operation reports pre-anaesthetic checklists etc, that do not have a dedicated section on the form.

Each Data Collection Form will have the following information already completed:

Side 1

- Project ID Number
- Patient's Age
- Patient's Sex

Side 2

- Project ID Number
- All nature of injury diagnoses codes
- All external cause codes

On Side 1 the coder will be required to complete:

- The Audit Date.
- Check box for Project ID – MRN validation.
- Admission date.

- Discharge date where Length of stay is greater than 1 day.
- Date of injury - where documentation confirms this.
- Narrative of all MR entries relevant to circumstances of injury, indicating the source documentation where necessary.
- All external cause, place of occurrence and activity codes as indicated by the abstracted narrative.
- In the top left hand corner the number of audit completed. The first Data Collection Form completed should be marked as “1” the next “2”. Therefore in a hospital where 50 MRs are being reviewed 50 Data Collection Sheets marked from 1 – 50 should be completed.

On side 2 the coder will be required to complete:

- Transposition of external cause codes from Side 1.
- Check box appropriate Modified ACBA categories to indicate any variance to the original code assignment.
- Explanation of reasoning behind coding decisions resulting in a variance of the codes.

Hospital Case List

Each hospital will provide the review coder with a copy of the “Hospital Case List” which will include all Project ID Numbers, the corresponding Medical Record Number (MRN), Patient's Names, Admission date and Discharge date for each case to be reviewed. The Medical Record Department (MRD) staff will provide the Medical Record (MR) for each case on the "Hospital Case List". It is likely that some MRs will be required by the hospital for clinics, patient care or other reasons; where any MR was not available for review indicate this on the Hospital Case List as n/a.

The Hospital Case List will be sent to each hospital in Project ID order. It will be easier to match MRs with the appropriate Data Collection Form by having the Hospital Case List printed in MRN order. To convert to MRN order have the MRD contact person open the Excel Spread sheet, Highlight the MRN Column, click the "Sort Ascending" icon, the one with the A above the Z and arrow beside it, you will be prompted to "expand the selection" do this. The rows of each list will now be arranged in MRN order for printing.

Data Collection Process

1. Select a medical record from those provided.

2. Locate the MRN on the Hospital Case List.
   Note: some "merged" MRs may have a different MRN on the MR cover than that indicated on the Hospital Case List. If you select a MR and the MRN is not on the list, before discarding this as a MR pulled in error, check that this is not a "merged" record by locating any admission notes with a discharge date between July 1 2002 And June 30 2004 - forms that have a MRN, or evidence of a MRN, different to that now on the MR cover and matching that on the Hospital Case List indicate a merged record: proceed with the Data Collection Process and indicate on the

Hospital Case List that this is a merged record and include the new MRN on the Hospital Case List.

3. Compare and confirm that the Patient's name on the MR matches that on the Hospital Case List.

4. Select the appropriate Data Collection Form indicated by the Project ID corresponding to the MRN.

5. Recheck that the Project ID on the Data Collection Form and the Project ID and MRN on the Hospital Case List correspond; and tick the check box marked "VALIDATE: MRN and Project ID Checked off Master List" on Side 1 of the Data Collection Form.

6. Enter the Audit date on Side 1 of the Data Collection Form
7. Transpose the Admission date from the Hospital Case List into the appropriate box on Side 1 of the Data Collection Form. If the Discharge date is different to the Admission date, enter the Discharge date below the admission date. This will be useful in referencing dated documentation

to identify its relevance to the separation being reviewed.

8. Rule a line through the Hospital Case List for this case.

9. Locate the appropriate admission according to the admission and discharge dates, and cover any original codes on the front sheet so they can not be seen during the review process.

10. Review the medical record for ANY information relating to the circumstances, place of occurrence and activity at time of injury and record this information in the appropriate sections of the Data Collection Form. As much as possible enter direct quotes of narrative, the Data Collection Form provides a General comments section where interpretations, logic on which coding decisions are based and notes can be documented.

11. Code all applicable external cause of injury, place of occurrence and activity codes according to the ACS (Australian Coding Standards) for ICD-10-AM Third Edition and enter them in the appropriate sections of Side 1 of the Data Collection Form. Enter any notes and comments you feel will clarify your reasoning behind your code selection.

NB: ALL applicable external cause of injury codes should be assigned regardless of local coding practice or system features that restrict the number of codes collected.

12. Transpose your code selections to Side 2 of the Data Collection Form.

13. Review your ICD-10-AM external cause code selection with that of the original coder. Where there is a variance review the MR to identify any documentation you may have missed, adjust code selections accordingly, noting the documentation sources.

14. Complete the Code Comparison sections on Side 2 of the Data Collection Form, indicating your reasoning for code selection where there is any variance with the original coder.

Reporting

A Report Template is provided to Report on each Project Location. Document information about the hospital, start and finish times. Use free text entry to indicate structure of the MR, any special External Cause data collection forms used (ask if you can forward an example of the original and/or current versions) and information on coding staff.

Quality of External Cause Coding

Medical Record Review

Example Report

<table>
<tr><td colspan="2">Hospital: Example</td><td colspan="2">Date: 23/ 08 / 07</td><td>No: 50 Coder: Ima Koolkat</td></tr>
<tr><td colspan="2">Contact: Ida Boss</td><td colspan="2">Ph: 3138 9753</td><td>Arrive: 06:45 Depart: 16:00
Coding Hrs: 9</td></tr>
<tr><td>Start time</td><td>Finish time</td><td>Project IDs</td><td colspan="2">Tasks /Comments</td></tr>
</table>

06:45	13:15	001 - 031	MR review
13:15	13:30		Lunch
13:30	16:00	032 - 050	MR review

Notes and Comments:

- Discharge Summaries are located in a separate section of the MR.
- As well as a Generic Discharge Summary Proforma a number of specialty Discharge Summaries (DCS) are used. Where used they are indicated in the Discharge Summary section of the Data Collection Form by the letters in parentheses:
    - Mental Health DCS (MH)
    - Emergency DCS and Referral (ED)
    - Paediatrics DCS (Paed)
- A very good data collection form is used here to capture details on external causes of injury. The Injury Proforma facilitates the collection of relevant data for ALL injury cases. The Example Health Inforamtion Service (HIS) has provided copies of the version in use during 3rd Edition and the current version, provided FYI. Forms attached.
- Information gathered from the Injury Proform has been preceded with the abbreviation IP-.
- Injury Proforma Collects:
    - When (Date and time)
    - Witnesses Yes/No and Who?
    - What went wrong to cause injury?
    - Also - Hx of Previous Injury, age, developmental health, interaction with caregiver, immunisation and examination findings.
- The Example HIS employs 7 FTE Coders and utilises Contract Coders on a monthly basis to handle backlogs.

- None of the current coding staff performed the coding function here during the study period 2002-2004.
- Very friendly and helpful staff.

International Classification of External Causes of Injury

You will not be required to code using the ICECI, however, Data Collectors should familiarise themselves with Section 2 of this Guide, the ICECI Data Collection Guide, to gain an understanding of ICECI coding capabilities. For example, in ICECI, objects and mechanisms are able to be coded as either an underlying, intermediate or direct cause of an injury; the role of the counterpart in transport accidents and the context in which an assault has occurred has an impact on code assignment. It will be necessary to have a good understanding of the concepts of the ICECI to ensure collection of all relevant narrative.

Remember that there are elements that can be captured using ICECI that can not in ICD-10-AM. A Quick Reference Sheet is provided below, more detail can be located in the body of the Guide.

Quick Reference Sheet: ICECI Data Collection Form - External Cause of Injury Coding

Element	Text Entries
C1: Intent **Page 20**	**Indicate all documentation relating to the intent.** Eg Patient stated he was accidentally pushed over balcony while wrestling with his brother. No apparent malice intended.
C2: Mechanism **Page 21**	**Indicate ALL mechanisms involved in event, whether underlying, intermediate or direct.** Eg: Unintentionally pushed by brother then slipped on wet balcony, hit head on pot plant and fell over railing onto roadway 3m below where he was run over by school bus.
C3: Object/Substance **Page 22**	**Indicate ALL objects involved in event, whether underlying, intermediate or direct.** Eg. Wet balcony, pot plant, railing, school bus.
C4: Place of Occurrence **Page 23**	**Indicate POO to finest detail available.** Eg. #1 Lounge room and balcony of 3rd floor unit, roadway. Eg # 2 In kitchen in house. Eg. #3 In dining room in Prison.
C5: Activity When Injured	**Indicate Activity at time of injury with as much detail as is possible.** Eg #1 Wresting with his brother.

Page 24	Eg #2 Paid working in retail sales of building materials and hardware
C6: Alcohol use **Page 25**	**Indicate all references to intoxication and any reported alcohol toxicology.**
	Eg. Patient stated that he and brother had drunk a carton of beer throughout the afternoon. Pt obviously intoxicated. Intoxicated + +. Etc.
C7: Psychoactive drug or substance use **Page 25**	**Indicate all possession of or intoxication of illicit drugs and any reported drug toxicology.**
	Eg. #1 Patients brother reported they had taken "Speed" earlier in the day. Eg # 2 Methamphetamine positive on bloods.
V1-V7: Violence **Page 31**	The Violence Module provides additional information about intentional injuries, whether self inflicted or directed at others. The module consists of seven data elements details of these are listed in the relevant section of this guide.
T1-T4: Transport **Page 37**	The Transport Module provides basic information about transport-related injuries. It has four data elements: Mode of transport, Role of the injured person, Counterpart, and Type of transport injury event.
P1-P7: Place **Page 42**	The Place Module provides more detailed information about where the injured person was when the injury event began. The module consists of seven data elements. These elements are listed in the table below, along with the first-level Place of occurrence codes to which they relate.

S1-S4: Sports **Page 55**	The type of sport or exercise activity in which the injured person was engaged at the time of the injury. Participation in a sport or exercise activity includes practice, training, and competition, as well as pre-event (e.g. taping, dressing), warm-up, cool down, and post-event (e.g., showering, dressing) activities. It does not include travel to and from the event or activity.
O1-O2: **Occupational** **Page 62**	The Occupational Module provides more information about the circumstances and setting of injuries that occur while a person is performing paid work**.** The current draft of the module consists of two data elements: Economic activity and Occupation.

Section 2

ICECI Data Collection Guide

Classification of International

Classification of External Causes of

Injuries (ICECI)

Section 2: ICECI Data Collection Guide

International Classification of External Causes of Injury Version 1.2

Contents

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O - OCCUPATIONAL MODULE

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Part C: Glossary of Terms

Part D: Index

Part A: Introduction to ICECI

The International Classification of External Causes of Injury (ICECI) is a system of classifications to enable systematic description of how injuries occur. It is designed especially to assist injury prevention. The ICECI was originally designed for use in settings in which information is recorded in a way that allows statistical reporting – for example, injury surveillance based on collection of information about cases attending a sample of hospital emergency departments. It has also been found useful for other purposes. For example, it has been used as a reference classification during revision of another classification, to record risk-factor exposure of children in a cohort study, as the basis for special purpose classifications and in a growing number of other ways.[1]

The ICECI is a Related Classification in the World Health Organization Family of International

Classifications (WHO-FIC). The ICECI is related to the External Causes chapter of the WHO

International Classification of Diseases (ICD).[2] Both the ICECI and the External Causes chapter of the ICD provide ways to classify and code external causes of injuries. Different design criteria have resulted in considerable differences between the two systems, and comprehensive mapping at fine level is not possible.[3]

The ICECI is multi-axial, modular and hierarchical. The multi-axial structure of the ICECI enables numerous factors to be recorded independently of one another. Coding of, for example, objects or substances involved in the occurrence of an injury is possible irrespective of how, or whether, other items have been coded (intent, for example).

The modular structure of the ICECI groups together sets of items which are likely to be used together. For example, the **Core** module includes items that are generally useful for injury surveillance. The **Sports** module includes items that might be used when sports injury is a special focus of a data collection. A data collection with a more general purpose might omit the **Sports** module, opting to rely on the less detailed coverage of external causes of sports injury provided by the **Core** module. The hierarchical structure of items in the ICECI allows users to choose from up to three levels of detail for data collection and reporting. The level used can differ between items and modules.

How to use this guide

The ICECI Data Collection Guide provides information about the ICECI and advice and direction on how to complete the ICECI Data Collection form located on the reverse side of the ICD-10-AM Injury and External Cause of Injury Data Collection form.

During the process of the data collection for ICD-10-AM Injury and External Cause of Injury Codes, detail on external cause of injury elements should be transferred to the ICECI data collection form. An understanding of ICECI data elements is necessary to document text relating to the external causes of injury into the appropriate section of the data collection form.

For example: Depending on the circumstances of an injury documentation relating to the role of a motor vehicle in an injury event may require that it be recorded in the ‘Object/Substance’ section and /or the ‘Transport’ section.

Part B of this guide contains the ICECI system organised into modules and items. It contains tables ordered according to ICECI code values. Data collectors need to have a thorough understanding of what items should be included in each data element, inclusion terms have been listed to assist in this process. Exclusion terms have been included where the resultant element should be coded to a different category. NB: The ICECI classification has a broader range of categories than are described in this guide. The purpose is of the data collection process is to identify data elements that can be captured in ICECI and allocate them to appropriate sections of the data collection form for later application of the ICECI codes. Examples are provided throughout the guide where further explanation of complex concepts important to application of the classification is considered necessary.

For many categories, Inclusion and Exclusion terms are provided to help specify the intended scope. Additional information is provided in this table for some categories. Read in conjunction with glossary definitions (Part C), information in the table for the item, and meta-information for the module in which it is located, is definitive.

Part C is a glossary of important terms used in the ICECI. When these words are used in the ICECI they are intended to have the meanings stated in the glossary.

Part D is an index to this version of the ICECI. The index is designed to assist users to find relevant categories in the tabular lists (Part B). The index contains a set of entries, arranged alphabetically. Most index entries refer to a single category in one ICECI coding item. Some entries refer to a single category in each of several ICECI coding items. This occurs when similarly-named categories appear in different parts of the coding system. For example, a bicycle can be involved in several ways as an external cause of injury. This is represented in the excerpt from the index shown here:

Bicycle

- Object C.3.1.01.05

- Mode of Transport T.1.2

- Transport Counterpart T.3.2

This index entry shows that a bicycle can be the mode of transport of the injured person, the

counterpart in a transport collision, or an object producing injury, whether or not in the context of

transport (eg. a bicycle could produce injury by falling on a person, or while it is being repaired, or in other ways). Every category in the tabular lists (Part B) is referred to by at least one index entry, normally worded in the same way as the corresponding category label in the tabular list.

Many categories in the tabular lists are also referred to by one or more additional index entries. These entries are designed to cater for variations, synonyms, subordinate concepts and alternative spellings.

Table 1: Examples of index terms

Code Index term Type

C.1.1 Unintentional Code label in tabular list

Accidental Synonym

C.2.1.1.3 Pedal cyclist Code label in tabular list

Cyclist pedal Variation of label

Bicyclist Synonym

C.3.11.02.25 Grinder, buffer, polisher, sander Code label in tabular list

Buffer Subordinate concept

Polisher " "

Sander " "

C.4.2.3 Prison Code label in tabular list

Police cell Specified inclusion

Gaol " "

Jail Alternative spelling

Guide to using the ICECI

ICECI as a basis for injury surveillance systems

Structure of the ICECI

Relationship between items in the Core Module and the Additional Modules

CORE MODULES

C1 Intent

C3 Object/Substance

C4 Place

C5 Activity

C6 Alcohol use

C7 Drug use

C2 Mechanism

Additional Modules

VIOLENCE

TRANSPORT

PLACE

OCCUPATIONAL

SPORTS

Core Modules

The **Core** module includes a set of items which were chosen to provide a good overview of the

external causes of injury cases in general. Mechanism records HOW the injury came about, and

Objects/Substances records WHAT types of things were involved in this process. Place gives insight into WHERE the injurious event occurred. The type of Activity of the person when injured can give insights that are useful for linking formal responsibilities (eg. of employers and others for occupational safety) to needs and opportunities for injury prevention. Intent captures the role of human Intent in the occurrence of injury. The ICECI also includes shortened versions of some modules that have not been included in this guide to avoid confusion; they are considered unnecessary for the purposes of this data collection process.

Additional Modules

The additional modules were designed to be used in conjunction with the **Core** module, each

supplementing its coverage in a particular area.

The **Violence** module provides additional items relevant to study of violence directed towards others (ie. assault, homicide, etc) and self-directed violence (ie. self-harm, suicide, etc). This module is linked to the Intent item in the Core module. Items in the Violence module are designed to be used for cases coded to certain Intent categories.

The **Transport** module provides additional items particularly relevant to road injury. The items are closely related conceptually to the section of the ICD-10 External Causes chapter covering this topic. This module is linked to the Mechanism item in the Core module. It is designed to enable capture of more detailed information about cases coded to Mechanism.

The **Place** module contains items which originate from a recognition that there are numerous ways to categorise locations. The place item in the Core module follows the approach taken in the ICD, which can be seen as grouping types of place largely according to typical patterns of authority and responsibility concerning them. The Place module supplements this with other categorisations of places, such as parts of places (eg. types of room, such as bathrooms) and further detail (eg. types of home). This module is linked to the Place item in the Core module and items in the Place module are designed to elaborate cases given certain values in the Core module Place item.

The **Sports** module provides a detailed classification of types of sport and related activities, and

includes items on protective factors. This Module is linked to the Activity item in the Core module.

The **Occupational** module provides classifications of occupations and industries, derived from United Nations standard classifications on these subjects. Occupation and industry are typically regarded as being very important components of injury data collections for occupational safety, because they enable data to be reported in ways relevant to economic sectors which have responsibility for prevention, and for other reasons. This Module is linked to the Activity item in the Core module.

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Part B: Modules

C - CORE MODULE

- C1 Intent
- C3 Object/Substance
- C4 Place
- C5 Activity
- C6 Alcohol use
- C7 Drug use
- C2 Mechanism

V - VIOLENCE MODULE

T - TRANSPORT MODULE

P - PLACE MODULE

S - SPORTS MODULE

O - OCCUPATIONAL MODULE

C - CORE MODULE

Introduction:

The Core Module includes a set of items which provide a good overview of the external causes of injury cases. It has seven data elements: Intent, Mechanism of injury, Object/substance producing injury, Place of occurrence, Activity when injured, Alcohol use and Psychoactive drug or other substance use.

Context:

Mechanism records HOW the injurious interaction took place, and Objects/Substances records

WHAT types of things were involved in this process. Place gives insight into WHERE the

injury event occurred. The type of Activity of the person when injured can give insights that

are useful for linking formal responsibilities (eg. of employers and others for occupational

safety) to needs and opportunities for injury prevention. The role of human Intent in the

occurrence of injuries has deep and sometimes complex relationships with the causes and

prevention of injury. Certain psycho-active substances are important risk factors for injury, and items are provided in the Core module for Alcohol Use and use of other Drugs.

C1 - INTENT

Definition:

The role of human purpose in the injury event.

Context:

Intent data provide information about the role of human intent in the occurrence of an injury.

This information can affect patient care and guide efforts to prevent injury recurrence. For example, the clinical and preventive approach to a person presenting with an injury is likely to differ, according to whether the injury is thought to be intentional or unintentional, and whether it is self-inflicted or inflicted by another. Personal, social, and legal sensitivities often apply to intentional conceptual reasons; determination of the intent of injury cases is often difficult.

Guide for use:

In general, intent is primarily determined by the incident and not by the resulting injury.

To capture information on Intent:

Select the term/s that best describes the intent of the injury event.

Injuries sustained by a bystander to a violent incident, or by a non-combatant in a conflict, are considered assault.

Injuries resulting from animal attacks are unintentional, unless the animal was used as a weapon by a person intent on inflicting injury.

Injuries to children under age five years who harm themselves are considered to be unintentional, except in the case of an individual who bangs their head in anger or frustration.

Notes:

The Intent data element includes the category complications of medical or surgical care.

The following categories of Intent indicate relevant data elements in the Violence Module.

When noted, refer to that module and document all appropriate data elements.

Intentional self-harm

Relevant data elements in Violence Module:

- proximal risk factors for Intentional self-harm
- previous suicide attempt

Legal intervention

Relevant data element in Violence Module:

- type of legal intervention

Operations of war or civil conflict

Relevant data element in Violence Module:

- type of conflict

C2 - MECHANISM OF INJURY

Definition:

The way in which the injury was sustained (ie., how the person was hurt).

Context:

Physical injury results when human tissue is acutely exposed to some form of energy and sustains some form of damage. An injury may also result from an insufficiency of any of the vital elements (eg., in drowning**/** near drowning, strangulation, or freezing). The process by which injury occurs may be described as the “mechanism of injury.”

Guide for use:

Injuries are often the result of a sequence of events. Different types of mechanisms are usually involved in the injury:

- Underlying mechanisms—those involved at the start of the injury event
- Direct mechanisms—those producing the actual physical harm
- Intermediate mechanisms—others mechanisms involved in the injury event.

The direct and underlying mechanisms may be the same.

For example, if a person cuts their finger with a knife while preparing food, the cutting of the finger is both the direct and underlying mechanism. Identifying the mechanism of injury in these situations is straightforward.

Other situations are more complex.

For example, if a woman trips over an appliance cord and hits her head on a counter, the tripping over the cord is the underlying mechanism (the action that starts the injury event), and the contact with the counter is the direct mechanism (the action that causes the actual physical harm).

In the example in Section 1, Figure 1.1, the fall from the ladder was the underlying mechanism, but the contact with the ladder is what actually caused the physical harm and is therefore the direct mechanism as well.

Because injury events often involve more than one mechanism, and because the sequence of events leading to an injury is not always clear, identifying the underlying mechanism of injury may be difficult. Moreover, information available in case notes does not always allow for distinguishing between types of mechanisms.

Mechanism of Injury has three levels of codes, with the third level being the most detailed.

To capture information relevant to Mechanism of Injury:

Document all mechanisms of injury at the most detailed level possible.

If it is possible to distinguish between types of mechanisms, document the underlying mechanism first, the direct mechanism and intermediate mechanism and tick the appropriate check box or boxes to indicate them as positively identified as such within the medical record.

If it is not possible to distinguish between types of mechanisms, document all mechanisms in the sequence they appear in the case information and do not tick the check boxes on the data collection from.

Notes:

Some categories in Mechanism of Injury note relevant data elements in the Transport Module which allows collection of additional details about transportation-related injury incidents. When the Mechanism of Injury is transport related, please refer to the Transport Module.

C3 - OBJECT/SUBSTANCE PRODUCING INJURY

Definition:

Matter, material or thing being involved in the injury event.

Context:

An **object** (eg., a car, heater, knife) or **substance** (eg., hot water, flames) conveys the mechanism of an injury. The aim of this data element is to provide specific categories for

Objects and substances commonly involved in producing injury, and broader categories for almost all objects and substances.

Guide for use:

Injuries are often the result of a sequence of events. Three types of objects/substances may be involved in the injury event:

- Underlying object/substance—the object/substance involved at the start of the injury event
- Direct object/substance—the object/substance producing the actual physical harm
- Intermediate objects/substances—other objects/substances involved in the injury event

The direct and underlying objects/substances may be the same.

For example, if a person cuts their finger with a knife while preparing food, the knife is involved at the start of the injury event, and it is the object that produces the actual physical harm. Identifying the object/substance in these situations is straightforward.

Other situations are more complex.

For example, if a woman trips over an appliance cord and hits her head on a counter, the appliance cord is the underlying object, and the counter is the direct object.

Some situations are further complicated by several objects producing injuries. In the case of a car crash, there may be an underlying object.

For example, the tree the car hit—and several direct objects, such as the steering wheel, the dashboard, and the windshield. Each of the direct objects may cause different injuries.

Injury events are not always a clear sequence of events involving objects/substances in clear succession. Moreover, information available in case notes often does not allow for distinguishing between the types of objects or substances.

Object/Substance Producing Injury has three levels of codes, the third level being the most detailed.

To capture information relevant to Object/Substance Producing Injury:

Document all objects/substances at the most detailed level possible.

If it is possible to distinguish between the different types of objects/substances, document the underlying object/substance first, followed by the direct object/substance. Last, document any intermediate objects/substances mentioned or thought relevant. Tick the appropriate check box or boxes to indicate them as positively identified as such within the medical record.

If it is not possible to distinguish between the different types of objects/substances, document objects/substances in the sequence they appear in the case information and do not tick the check boxes on the data collection from.

C4 - PLACE OF OCCURRENCE

Definition:

Where the injured person was when the injury event started.

Context:

Place of Occurrence data help group injuries by areas of responsibility and may help injury prevention practitioners better target interventions and use resources more effectively. This information can also provide insight into injury aetiology.

Guide for use:

Place of Occurrence in ICECI classification has two coding levels, the second level being more detailed. Not all places, however, have a second coding level.

NOTE: The codes represent where the injured person was when the injury event **began**, not when the injury event ended.

To capture information relevant to the Place of Occurrence:

Document full detail of the place or places where the injury event began.

Look for documentation referring to the whole entity (ie., a structure or space owned or operated as a whole) within which an injury occurred, and then document places referring to only a part or parts of such an entity. Provide as much fine detail as contained in documentation within the medical record.

For example, if an injury occurs while being in a indoor swimming pool in a holiday park; document Holiday Park, Swimming pool and Indoors.

If more than one injury is involved, and those injuries occurred in different places document both places on separate lines of the data collection form.

In general, places include attached grounds, outbuildings, etc.

For example, Home includes the dwelling and any associated garden, garage, shed, etc. Likewise, Factory/plant includes buildings and premises like roadways, parking areas, and industrial yards.

Notes:

Some categories in Place of Occurrence note relevant data elements in the Place Module. This allows for coding additional details about where the injury event occurred. Please refer to the Place Module for guidance in collecting further information relevant to applying the ICECI codes to Place of Occurrence.

C5 - ACTIVITY WHEN INJURED

Definition:

The type of activity the injured person was engaged in when the injury occurred.

Context:

Activity when injured data allow injury cases to be grouped into categories that correspond to areas of responsibility for injury prevention. Being able to identify, for example, injuries that occur while a person is working or injuries that occur while playing a sport may help guide development of more effective prevention strategies.

Guide for use:

When collecting information relevant to Activity when injured, determine the area of responsibility and the main purpose of the activity. If there is more than one area of responsibility document them all. For example occupational and sports injury events; educational and sports injury events; occupational and traffic injury events; and sports and exercise during leisure time and leisure and play activities.

To capture information relevant to Activity when injured:

Document the activity that best describes the activity the injured person was engaged in when the injury occurred.

If two or more activities are judged to be equally appropriate, document them all.

Some categories in Activity note relevant data elements in the Occupational Module or Sports Module. This allows for coding additional details about the activity of the injured person when the injury event occurred.

Where the injury is related to occupational or sports activity please refer to the Occupational or Sports Module for guidance in collecting further information relevant to applying the ICECI codes to Activity.

C6 - ALCOHOL USE

Definition:

Suspicion or evidence of alcohol use preceding the injury event by the injured person and/or other persons involved in the injury event.

Context:

Alcohol use is a known risk factor for injuries. Therefore, it is important to collect information about the involvement of alcohol use in injury events. In some cases, biological quantitative information about alcohol use (eg., blood or breath alcohol level) is available. In other cases, one may merely suspect alcohol use (eg., if the patient smells of alcohol). This data element indicates whether there is either suspicion or evidence of alcohol use. No distinction is made between suspicion and evidence because criteria for each category are too difficult to define.

Guide for use:

Document information relevant to this item for each injury case, regardless of the severity of injury, age of the injured person, or intent of the injury event.

If more information is available (eg., type of suspicion or evidence, characterisation of others involved in the injury event), please add this detail to the narrative.

C7 - PSYCHOACTIVE DRUG OR SUBSTANCE USE

Definition:

Suspicion or evidence of psychoactive drug use (eg., opiates, cocaine, amphetamines, cannabinoids, sedatives, hypnotics) or other psychoactive substance use (eg., hair spray, gasoline, glue) preceding the injury event by the injured person and/or other persons involved in the injury event.

Context:

Use of psychoactive drugs or other substances is a known risk factor for injuries. Therefore, it is important to collect information about the involvement of drug use and other substance use in injury events. In some cases, biological quantitative information about drug or substance use (eg., blood/urine drug level) is available. In other cases, one may merely suspect drug or substance use (eg., if the patient has injection marks). This data element indicates whether there is either suspicion or evidence of alcohol use. No distinction is made between suspicion and evidence because criteria for each category are too difficult to define.

Guide for use:

Document information relevant to this data item for each injury case, regardless of the severity of injury, age of the injured person, or intent of the injury event.

If more information is available (eg., type of suspicion or evidence, characterisation of others involved in the injury event), please add this detail to the narrative.

ADDITIONAL MODULES

Introduction:

There are five Additional Modules: Violence, Transport, Place, Sports and Occupation. Each of theses additional modules contain data elements which capture fine detail of external causes of injury cases.

Each of the data elements have inclusion terms and examples, where necessary, to guide data collectors. The inclusion terms and examples generally describe the subcategories that exist within the ICECI classification and should be used as a guide by data collectors as to the type and detail of external cause information that can be captured, and therefore should be documented on the data collection form. However, because of the scope of the ICECI it is not possible to describe all subcategories of levels of coding within each data element.

Data collectors should provide as much detail on external causes as is available within the medical record and where possible identify the human and documentary sources of the information

For example:

Psychoactive drug or substance use	BIB Police report to ED: Pt "High", 2 ecstasy tabs in pocket, at time of arrest.
	Blood tests: methyl-amphetamine level .034 ppv, cannabis .095 ppv,
Violence: Patient / Relative / Friend ◻ Doctor / Nurse/ Police ◻ Other / Not Indicated ◻	Patient: Stabbed with ice-pick by unknown female person. Police: Probable drug deal gone wrong
	Hit head on car roof while trying to escape police custody
Perpetrator:	
Transport:	

V - VIOLENCE MODULE

V1 - PROXIMAL RISK FACTORS FOR INTENTIONAL SELF-HARM

V2 - PREVIOUS SUICIDE ATTEMPT

V3 - VICTIM/PERPETRATOR RELATIONSHIP

V4 - SEX OF PERPETRATOR

V5 - CONTEXT OF ASSAULT

V6 - TYPE OF LEGAL INTERVENTION

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T - TRANSPORT MODULE

T1 - MODE OF TRANSPORT

T2 - ROLE OF THE INJURED PERSON

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P7 - INSIDE/OUTSIDE CITY LIMITS

S - SPORTS MODULE

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S2 - PHASE OF ACTIVITY

S3 - PERSONAL COUNTERMEASURES

S4 - ENVIRONMENTAL COUNTERMEASURES

O - OCCUPATIONAL MODULE

O1 - ECONOMIC ACTIVITY

O2 - OCCUPATION

V - VIOLENCE MODULE

Introduction:

The Violence Module provides additional information about intentional injuries, whether self inflicted or directed at others. The module consists of seven data elements which are listed below.

Violence Module Data Elements

V1 Proximal risk factors for intentional self-harm

V2 Previous suicide attempt

V3 Victim/perpetrator relationship

V4 Sex of perpetrator

V5 Context of assault

V6 Type of legal intervention

V7 Type of conflict

Context:

The Violence Module provides data collectors with uniform code sets to better describe the problem of fatal and nonfatal injuries related to violence. The data from this module can help practitioners identify circumstances that put individuals at risk for violence-related injury and guide development of prevention strategies.

Guide for use:

When collecting information related to violent injuries, two major issues must be considered.

Firstly, certain types of intentional injury events tend to be missed. For example, abuse of

partners, children, and elders may masquerade as unintentional injury event. While the emergency room is probably the best single source of data, one must recognise that information about injuries and events leading up to them will most likely be elicited from the victim, with attendant personal biases.

Secondly, extreme care, sensitivity, and confidentiality must be exercised in extracting information from patients who have already undergone trauma from a violent event. Therefore, Persons who gather and document injury information must be highly sensitised and well trained.

To capture information relevant to Violent injury:

Document each relevant data element documented in the medical record relating to Violent injury.

Where possible, indicate the main source(s) of information related to violent injuries by ticking the appropriate box on the data collection form. Delete any informant not relevant to the source of information.

Patient / Relative / Friend □

Doctor / Nurse/ Police □

Other / Not Indicated □

V1 - PROXIMAL RISK FACTORS FOR INTENTIONAL SELF-HARM

Definition:

The most recent crises that led to the self-harm incident.

Context:

In many countries, intentional self-harm contributes to a large number of injuries. To better understand injuries related to this type of violence, it is important to collect information about factors that may be associated with such events. This information will help guide development of effective prevention strategies.

Guide for use:

Document information related to this data element, for all injuries related to intentional self-harm, only when clearly documented in the medical record.

Indicate clearly on the data collection form who made the note and include any descriptions that question the degree of certainty with which the documentation refers.

For example: Query unwanted pregnancy – psychiatric assessment by case worker.

Note:

This classification is among the most “exploratory” classifications in the ICECI. Little is known

about the relationship between suicide events and some of the factors listed in the codes. These factors may be associated with the event, but the degree to which they precipitated it is unknown. Therefore, data collected by using this element may contribute to the formulation of hypotheses to elucidate these relationships.

To capture information relevant to Proximal Risk Factors where intentional self harm:

Document each relevant data element noted in documentation within the medical record that relate to proximal risk factors as listed below..

V1 - Proximal Risk Factors For Intentional Self-Harm:

Overview of Codes

1 Conflict in relationship with family member, partner, or friend - Identify the particular family member or unspecified.

2 Death of a relative, partner, or friend - Identify if suicide or other manner of death.

3 Physical problem - HIV, unwanted pregnancy, other, unspecified.

4 Psychological/psychiatric condition - Substance abuse, post partum depression, other, unspecified.

5 Income-related/financial problem - Work related, dowry, other, unspecified.

6 Abuse - Sexual abuse, physical abuse, neglect, other, unspecified.

7 Legal system encounter - While incarcerated.

8 Other specified proximal risk factor - School related, religious belief or affiliation, cultural issue, other, unspecified.

9 Unspecified proximal risk factor - Proximal risk factor NOS.

V2 - PREVIOUS SUICIDE ATTEMPT

Definition:

Whether or not the injured person attempted suicide before.

Context:

This variable gives behavioural scientists insight into the ratio of “first-timers” to repeat attempters.

Guide for use:

Document this data element for all injuries related to intentional self-harm.

To capture information relevant to Previous Suicide Attempts:

Identify if there is documentation in the medical record of previous suicide attempts.

V3 - VICTIM/PERPETRATOR RELATIONSHIP

Definition:

The relationship of the person committing the violent act to the injured person.

Context:

Intentional injury surveillance systems collect mainly information about injured persons. However, to better understand the type of violence (eg., family violence vs. violence committed by strangers), it is important to collect information about the person(s) inflicting the injury. Such information will help determine the main types of violence that are prevalent in a society and will help practitioners develop effective prevention strategies.

Guide for use:

Document information relevant to his data element for all injuries related to assault.

Note that for this surveillance, the use of the words “victim” and “perpetrator” imply no judgement, legal or otherwise.

To capture information relevant to the Victim and Perpetrator Relationships:

Identify the relationship of all perpetrators, documented in the medical record, to the victim at the time of the incident.

If there are several perpetrators, further identify information about the perpetrator who contributed most to the injury.

Document each perpetrator noted in documentation within the medical record that relate to categories listed below.

V3 - Perpetrator/Victim Relationship

1 Spouse or partner - Legal spouse, co-habiting partner, non-cohabiting partner, ex-spouse, ex-partner, unspecified spouse or partner.

2 Parent - Mother, father, step parent, unspecified parent.

3 Other relative - Full sibling, half sibling, step sibling, grandparent, off spring, other blood relative, in-laws, other specified relative, unspecified relative.

4 Unrelated care giver - Foster parent, care giver in institution, health care provider, other, unspecified.

5 Acquaintance or friend - Parent's boyfriend/girlfriend/non-cohabiting partner, date, room mate, business relation, neighbour, institutional co-member, work mate, class mate, other, unspecified.

6 Official or legal authority - Military, police, other official authority, security guard, civilian authority, other, unspecified.

7 Stranger - Vigilante group, mob, other, unspecified.

8 Other specified relationship - Prisoner, detainee, person executing or interceding in a felony/crime, other specified.

9 Unspecified relationship - Unspecified.

V4 - SEX OF PERPETRATOR

Definition:

The sex of the person who inflicted the injury.

Context:

This data element provides additional information about the person who caused the violent injury.

Guide for use:

Document information relevant to his data element for all injuries related to assault.

V4 - Sex Of Perpetrator

1 Male

2 Female

9 Unknown

V5 - CONTEXT OF ASSAULT

Definition:

The circumstances surrounding the violent injury event.

Context:

A large number of injuries occur during assaults. However, little is known about the type of assaults during which injuries occur (eg., family quarrels, drug-related incidents, gang-related violence, etc.). To better understand violence-related injuries, it is important to collect information about the circumstances in which injury-causing assaults occur. This information can help guide development of prevention strategies.

Guide for use:

Document information relevant to his data element for all injuries related to assault.

To capture information relevant to the Victim and Perpetrator Relationships:

Identify any details relating to the context of the assault documented in the medical record.

V5 - Context Of Assault

1 Altercation - Includes: Disagreement, argument, quarrel about:

Family issues -children, in-laws, dowry, family honour, other specified family issues, unspecified family issues

Personal issues -current love relationship, terminating a love relationship, desertion

Sex - sexual jealousy, rivalry over a lover, love triangle altercation, rejection

Other specified and unspecified personal issues

Personally-held views – politics, religious or spiritual matters, cultural issues, racial/ethnic issues, gender and/or sexual orientation, other specified, unspecified personal views

About business/financial issues - loss of employment, other financial losses related to employment or business, other employment disputes, money or property (Land, food, or other possessions), other specified, unspecified business/financial issue.

About sports and other leisure - About gambling (wagering on a sporting event), sports, other specified, unspecified leisure activity.

Other specified altercation - traffic, malicious misconduct, speaking ill of person(s), bullying, intimidation, past altercation, other specified, unspecified altercation

Excludes:

Drug-related altercation (3)

Sexual assault (4)

Drug-related business (3)

2 Illegal acquisition or attempted illegal acquisition of money or

Property - Burglary (attempted), robbery - (attempted), whether armed or unarmed, type of weapon, unspecified robbery, other specified, unspecified illegal/attempted illegal acquisition

Excludes:

- drugs as property (3)
- kidnapping (6.2)

3 Drug-related incident - Selling drugs/drug business, argument over possession, use, or cost of drugs, failure to pay a drug debt, probable drug involvement, but no positive evidence, other specified, unspecified drug-related incident

4 Sexual assault - Rape, attempted rape, penetration with an object, type of object, sodomy, attempted sodomy, Touching or fondling of genitals, oral sex, other specified, unspecified sexual assault

5 Gang-related incident - Gang initiation, gang rivalry, other specified, unspecified gang-related incident

6 Other criminal activity - Blackmail, extortion, kidnapping, ransom, contract injuring or killing, drive-by shooting, other specified, unspecified or suspected criminal activity

Excludes:

- theft (2)
- drug-related crime (3)
- sex-related crime (4)

8 Other specified context of assault - Retaliation/revenge, Mercy killing, euthanasia, attempted mercy killing or euthanasia, neglect, torture, mistaken identity, other specified, unspecified context of assault

V6 - TYPE OF LEGAL INTERVENTION

Definition:

The type of legal intervention during which a person was injured.

Context:

Details about injuries caused in the course of legal intervention may provide information to guide injuries related to law enforcement.

Guide for use:

Document information relevant to his data element for all injuries inflicted by a law enforcement officer acting in an official capacity.

Include injuries inflicted by an object or animal that may be considered an extension of the officer (eg., a police dog).

Select the category that best describes the type of legal intervention. If two or more categories are judged to be equally appropriate, select the gravest situation operating at the time of the incident.

Note:

The victim will typically be a suspect or bystander. If an officer is the victim, consider the injury event an assault, not related to legal intervention. The only exception is if the officer is injured by another officer in the line of duty.

V6 - Type Of Legal Intervention

1 Potential arrest situation - Traffic pursuit, refusal to stop or pull over, investigation of a suspicious person or incident, execution of a search warrant, execution of an arrest, other specified , unspecified arrest situation

2 Response to a disturbance call - Family dispute, Person behaving aberrantly, Other specified disturbance call, bar fight, unspecified disturbance call

3 Ambush situation - Entrance or invasion of premises without warning or notice, situation with a deliberate element of surprise, drug raid.

4 Civil disorder - mass disobedience, riot.

5 Handling, transporting, custody of prisoner(s)

6 Execution of a legal sentence – whipping, caning, other forms of corporal punishment and capital punishment as ordered by a judge.

8 Other specified type of legal intervention

9 Unspecified type of legal intervention

V7 - TYPE OF CONFLICT

Definition:

Type of war or civil conflict underway when the injury occurred.

Context:

It is exceedingly difficult to collect data during times of war or civil conflict. However, some attempt has been made to distinguish between the various types of conflict. The information collected for this data element is especially useful when combined with demographic information about the victim (including whether civilian or military); the type of weapon used (coded in Mechanism of injury or Object/substance producing injury); and the source of conflict (coded in Context of assault).

Guide for use:

Document information relevant to his data element for all injuries related to operations of war or civil conflict.

V7 - Type Of Conflict

1 Civil war/guerrilla operation - Organised conflict between groups or factions within one country, revolution, coup d'etat.

2 War - Conflict between two or more countries.

3 Terrorism

4 Civil insurrection - riots, protests, strikes, sit downs, blockages, etc.

5 Post-conflict incident - explosion of devices (eg., mines) placed during the conflict

8 Other specified type of conflict

9 Unspecified type of conflict

T - TRANSPORT MODULE

T1 - MODE OF TRANSPORT

T2 - ROLE OF THE INJURED PERSON

T3 – COUNTERPART

T4 - TYPE OF TRANSPORT INJURY EVENT

Introduction:

The Transport Module provides basic information about transport-related injuries. It has four data elements: Mode of transport, Role of the injured person, Counterpart, and Type of transport injury event.

Context:

This module is designed to collect data about the circumstances in which these injuries occur. Such information can help guide prevention strategies. Neither the basic ICECI nor this module is designed to code detailed information about transport injury events, such as road conditions, speeding, or the use of occupant restraints. However, this information, when it is available, may be recorded in a text description of how the injury occurred. It may also be possible to document information relevant to Object/substance producing injury to identify some objects involved in collisions (eg, a tree).

Guide for use:

Identify data in the Transport Module for all injuries that involve a device designed primarily for, and being used at the time primarily for, conveying persons or goods from one place to another.

Always document information relevant to all four data elements for this module.

Transport devices include:

- land transport vehicles, including on- and off-road vehicles, which may or may not be motor

driven

- watercraft
- aircraft

Identify an injury to a person travelling on foot or using a pedestrian conveyance only when a

transport device is involved.

Notes about inclusions:

A transport device must be involved in the injury event.

The injured person may be: a pedestrian, including user of a pedestrian conveyance (eg., baby carriage or stroller, in-line skates, wheelchair) a user of a transport device. The injured person does not have to be a user of a transport device or a pedestrian. All of the following would be included:

a person at a sidewalk café who was hit by a car that went out of control

a swimmer who was hit by a boat

a person on the ground who was injured when a plane crashed

Transport injury events include falls in or from the following transport devices when they were

not involved in a derailment, collision, or crash:

railway trains or rail vehicles and streetcars

watercraft

aircraft (including injuries to parachutists)

Transport injury events also include: poisoning from exhaust gas generated by a vehicle in motion

injury from being thrown against some part of, or object in, a vehicle in motion injury from a moving part of a vehicle in motion (eg., catching one's hand or neck in a moving car window)

injuries associated with machinery on board watercraft (see Type of Transport Injury data element for details).

Notes about exclusions:

The following types of events are not considered transport injury events.

Events in which pedestrians, or persons using pedestrian conveyances, are injured but there is no involvement of a transport device.

For example: None of the following would be included:

a pedestrian who fell on a sidewalk,

an in-line skater who collided with a utility pole,

a person in a wheelchair who collided with a pedestrian.

Events due to cataclysm (earthquake, volcanic eruption, avalanche, landslide or other earth movement, cataclysmic storm, flood).

For example: Neither of the following would be included:

injury due to a vehicle being caught in an avalanche or landslide,

injury to a motorcyclist swept off the road by a sudden flood.

Events unrelated to the movement or operation of a transport device.

For example: Neither of the following events would be included:

a child putting a bean in her ear while riding in a car, being stung by a bee while riding in a car (as long as it did not result in loss of control and a collision or crash)

Events involving land transport devices not in use for transport at the time.

For example: An injury due to a vehicle under repair in a garage or driveway falling on the person repairing it)

T1 - MODE OF TRANSPORT

Definition:

The means by which the injured person was travelling from one place to another.

Context:

The way in which the injured person was travelling (eg., on foot, in an on- or off-road vehicle, in watercraft) is the most important factor to identify for use in preventing transport injuries. This information is classified using the Mode of Transport data element, which is based on the information for categories V01 to V99 in Chapter XX of ICD-10.

Guide for use:

Code Mode of Transport whenever the Transport Module is used.

Select the code that best characterises how the injured person was travelling or, if not travelling, what he or she was doing at the time of injury in the context of a transport event. Therefore, the 'activity' (or what the injured person was doing at the time of the injury) is to be interpreted in the context of the specific codes listed in the transport module.

For example: If a child was riding a bicycle for leisure around his home, fell off, and got injured, then the mode of transport would be pedal cycle.

If the injured person is described as crushed, dragged, hit, injured, killed, knocked down, or run over by any vehicle, and the transport event description does not specify the injured person as being a vehicle occupant, document the injured person as a pedestrian.

If the injured person's mode of transport is not identified but it is known that the event was a collision, crash, wreck, or other injury event involving a car, bicycle, or other specified vehicle, document the injured person as a user of the vehicle mentioned.

If the injured person's mode of transport is not identified and more than one vehicle is mentioned, do not assume which vehicle the victim occupied unless the vehicles are the same (eg. all cars). Instead, document Unspecified mode of transport.

Note that a person boarding or alighting from a vehicle is considered a user of the vehicle.

T1 - Mode Of Transport

1 Pedestrian - Person on foot, person at the side of the road, changing tyre of a vehicle, making adjustment to the motor of a vehicle, bystander, person using a pedestrian conveyance, ice and in-line skates, skis, sled, push-cart, motorised or hand-powered wheelchair, the person riding in, as well as the person pushing or pulling, a baby carriage/stroller, wheelchair, person-drawn rickshaw, etc.

2 Pedal cycle - unpowered bicycle, unpowered tricycle, cycle rickshaw.

Excludes:

Motorised pedal cycle (4.1 or 4.2)

Child’s toy tricycle (not a transport device)

3 Other non-motorised transport device - Animal-drawn vehicle, animal being ridden, other specified , unspecified non-motorised transport device.

4 Two-wheeled motor vehicle - Motorised bicycle, moped, Vespa, scooter model of motorised bicycle, motorcycle, motorcycle with sidecar, scooter model of motorcycle, other specified, unspecified two-wheeled motor vehicle

Excludes:

Motorised tricycle (5)

Dirt bike (10.8)

5 Three-wheeled motor vehicle - motorised tricycle, motorised rickshaw, three-wheeled motor car.

Excludes:

Three-wheeled all-terrain vehicle (10.8)

6 Light transport vehicle with four or more wheels - Motor car, station wagon, minivan, jeep, sport utility vehicle, 4x4, vehicle with up to 10 seats, minibus, passenger van, vehicle with 11-19 seats, goods or work van, ambulance, motor home, light transport vehicle with four or more wheels used in sport and leisure activities, go cart, racing car, golf cart, other specified, unspecified light transport vehicle with four or more wheels

Excludes:

Four-wheeled all-terrain vehicle (10.8)

Bus, coach (7.1)

7 Heavy transport vehicle - Bus or coach, vehicle with 20 or more seats, truck, tractor-trailer, articulated lorry, 18-wheeler, rig, panel truck, fire truck, tow truck, other specified, unspecified heavy transport vehicle

Excludes:

Minibus, passenger van (6.2)

Pick-up truck, goods or work van (6.3)

8 Rail vehicle - Railway train, streetcar, tram, funicular, monorail, other specified, unspecified rail vehicle

Excludes:

Cable car, not on rails (98)

Ski chair-lift (98)

Ski lift with gondola (98)

9 Special industrial, agricultural, or construction vehicle - Special vehicle used in industry, battery-powered airport passenger vehicle, forklift, coal-car in mine, special vehicle used in agriculture, tractor, combine, self-propelled farm machinery, special vehicle used in construction, bulldozer, digger, mechanical shovel, dump truck.

Excludes:

Vehicle in stationary use or maintenance (not considered a transport device)

10 Special all-terrain or off-road vehicle – Snowmobile, hovercraft operating on land or swamp, other specified all-terrain or off-road vehicle, dirt bike, three- or four-wheeled all-terrain vehicle, quad motorcycle, dune buggy, unspecified all-terrain or off-road vehicle.

11 Watercraft - Merchant ship, cargo ship, freighter, oil tanker, passenger ship, ferry, ocean/passenger liner, cruise ship, fishing boat, trawler, other specified powered (motorized) watercraft, dingy (dinghy)/rowboat with outboard motor, hovercraft in use over water, land or swamp, houseboat, motorboat, powered boat, motorized yacht, personal powered watercraft, submarine, sailboat, unpowered yacht, other specified unpowered watercraft, dingy (dinghy)/rowboat – unpowered, kayak, canoe, inflatable raft, raft NOS, paddle ski, pirogue, piragua, schooner, tall ship, surf board, unpowered watercraft NOS, wave board, windsurfer, watercraft, unspecified as powered or unpowered.

12 Aircraft - Powered aircraft, airplane, aeroplane, helicopter, ultralight, microlight, powered glider, blimp, dirigible, space craft, unpowered aircraft, balloon, glider, hang-glider, space craft, parachute used in descent from damaged aircraft, parachute used in descent from undamaged aircraft, parachute used in voluntary jump from undamaged aircraft, unspecified aircraft.

98 Other specified mode of transport - Cable car (not on rails), ice- and land-yacht, ski chair-lift, ski lift with gondola

Excludes:

Other non-motorised transport devices (3.1–3.9)

99 Unspecified mode of transport

T2 - ROLE OF THE INJURED PERSON

Definition:

How the injured person was involved with the specified mode of transport at the time of the injury event.

Context:

A person injured in a transport injury event was fulfilling one of a variety of roles at the time of injury. Examples of common roles are driver (or rider) of a vehicle (or animal) and passenger in a vehicle. This information is classified using the Role of the Injured Person data element, which is based on the fourth character codes for categories V01 to V79 in Chapter XX of ICD-10.

Guide for use:

Document the Role of the Injured Person for all transport injury events.

Document that which best characterises the role of the injured person, with respect to the Mode of transport.

If the transport event description does not indicate the injured person’s role (eg. all that is known is that the event was a car or bicycle collision, crash, wreck, or other injury event), document the role of the injured person as unspecified (9).

T2 - Role Of The Injured Person

1 Person on foot, bystander

2 Driver, rider, or operator - Person driving a motor vehicle, person riding a pedal cycle, person pushing or pulling a pedestrian conveyance (eg., wheelchair, baby carriage)

3 Passenger - Person in a sidecar or trailer attached to a transport vehicle, person riding in the cargo area of a truck, including the back of a pickup truck, person riding in a pedestrian conveyance that is pulled or pushed by another person (eg., rickshaw, baby carriage)

4 Person boarding or alighting a vehicle - Person getting into/on or out of/off a transport vehicle, including a pedal cycle, or pedestrian conveyance

5 Person on outside of vehicle - Person travelling on bodywork, bumper or fender, roof rack, running board or step, hanging onto the outside of a vehicle

6 Vehicle occupant not otherwise specified

8 Other specified role of the injured person

9 Unspecified role of the injured person

T3 – COUNTERPART

Definition:

The other vehicle, object, person, or animal (if any) with which the injured person, or the vehicle in which the injured person was travelling, collided.

Context:

Many transport injury events involve collision of the injured person, or the vehicle in which the injured person was travelling, with one or more other people, animals, vehicles, or objects. These are referred to as counterparts. In some events (eg. if a car rolls in a ditch, without a prior collision), there is no counterpart. This information is classified using the Counterpart data element, which is based on the information for categories V01 to V80 in Chapter XX of ICD-10.

Guide for use:

Document the Counterpart whenever the transport module is used.

Document that which best characterises the counterpart of the injured person or of the vehicle in or on which the injured person was travelling. Note that parked vehicles are classified as fixed or stationary objects (13.1).

Document No counterpart (15) only if there is no collision.

Record the counterpart even if a collision occurred after, and perhaps because of, another event such as loss of control due to:

a burst tyre, driver inattention,

excessive speed,

a vehicle being hit by an object thrown at it or dropped onto it.

If the injury event was caused by something being thrown at, dropping on, or falling on a vehicle, document as follows:

If loss of control of the vehicle resulted in a subsequent collision, document the counterpart as the item with which the vehicle subsequently collided.

If loss of control of the vehicle resulted in a rollover, if the injury was due to a sudden stop

or swerving, or if the injury was directly due to the thrown, dropped, or falling object,

document No counterpart (15).

A thrown, dropped, or falling object may be classified using the Object or Substance Producing Injury codes (C3).

T3 – Counterpart

1 Pedestrian - Person on foot, person at the side of the road, changing tyre of a vehicle, making adjustment to the motor of a vehicle, bystander, person NEC or NOS, person using a pedestrian conveyance, ice and in-line skates, skis, sled, push-cart, motorised or hand-powered wheelchair, the person riding in, as well as the person pushing or pulling, a baby carriage/stroller, wheelchair, person-drawn rickshaw, etc.

2 Pedal cycle - Unpowered bicycle, unpowered tricycle, cycle rickshaw

3 Other non-motorised transport device - Animal-drawn vehicle, animal being ridden, other specified, unspecified non-motorised transport device

4 Two-wheeled motor vehicle - Motorised bicycle, moped, Vespa, scooter model of motorised bicycle, motorcycle, motorcycle with sidecar, scooter model of motorcycle, other specified, unspecified two-wheeled motor vehicle

Excludes:

- dirt bike (10.8)

5 Three-wheeled motor vehicle - motorised tricycle, motorised rickshaw, three-wheeled motor car

Excludes:

 three-wheeled all-terrain vehicle (10.8)

6 Light transport vehicle with four or more wheels - Motor car, station wagon, minivan, jeep, sport utility vehicle, 4x4, vehicle with up to 10 seats, minibus, passenger van, vehicle with 11-19 seats, pick-up truck, goods or work van, ambulance, motor home, light transport vehicle with four or more wheels used in sport and leisure activities, go cart, racing car, golf cart, other specified, unspecified light transport vehicle with four or more wheels.

Excludes:

Four-wheeled all-terrain vehicle (10.8)

Bus, coach (7.1)

7 Heavy transport vehicle - Bus or coach, vehicles with 20 or more seats, truck, tractor-trailer, articulated lorry, 18-wheeler, rig, panel truck, fire truck, tow truck, other specified, unspecified heavy transport vehicle.

Excludes:

Minibus, passenger van (6.2)

Pick-up truck, goods or work van (6.3)

8 Rail vehicle - Railway train, streetcar, tram, funicular, monorail, other specified, unspecified rail vehicle.

Excludes:

- cable car, not on rails (98)
- ski chair-lift (98)
- ski lift with gondola (98)

9 Special industrial, agricultural, or construction vehicle - Special vehicle used in industry, battery-powered airport passenger vehicle, forklift, coal-car in mine, s**pecial vehicle used in agriculture,** tractor, combine, self-propelled farm machinery, s**pecial vehicle used in construction,** bulldozer, digger, mechanical shovel, dump truck

Excludes:

- vehicle in stationary use or maintenance (not considered a transport device)

10 Special all-terrain or off-road vehicle – Snowmobile, hovercraft operating on land or swamp, other specified all-terrain or off-road vehicle, dirt bike, three- or four-wheeled all-terrain vehicle, quad motorcycle, dune buggy, unspecified all-terrain or off-road vehicle.

11 Watercraft - Merchant ship, cargo ship, freighter, oil tanker, passenger ship, ferry, ocean/passenger liner, cruise ship, fishing boat, trawler, other specified powered (motorized) watercraft, dingy (dinghy)/rowboat with outboard motor, hovercraft in use over water, land or swamp, houseboat, motorboat, powered boat, motorized yacht, personal powered watercraft, submarine, sailboat, unpowered yacht, other specified unpowered watercraft, dingy (dinghy)/rowboat – unpowered, kayak, canoe, inflatable raft, raft NOS, paddle ski, pirogue, piragua, schooner, tall ship, surf board, unpowered watercraft NOS, wave board, windsurfer, watercraft, unspecified as powered or unpowered.

12 Aircraft - Powered aircraft, airplane, aeroplane, helicopter, ultralight, microlight, powered glider, blimp, dirigible, space craft, unpowered aircraft, balloon, glider, hang-glider, space craft, parachute used in descent from damaged aircraft, parachute used in descent from undamaged aircraft, parachute used in voluntary jump from undamaged aircraft, unspecified aircraft.

13 Fixed or stationary object - Vehicle parked at the side of a road or in a parking lot, small loose object, fallen stone or rock, tree branch, small or light fixed object, small pole, traffic sign, bush, small tree, large or heavy fixed object, utility pole, hydrant, large or unspecified tree, guard rail or boundary fence, bridge or overpass abutment, safety island, inter-highway divider, building, other specified fixed or stationary object, boulder, landslide or avalanche (not in motion), wall of hillside cut for road, unspecified fixed or stationary object.

14 Animal - Unattended animal, animal being herded, other specified, unspecified animal.

Excludes:

- animal pulling a conveyance (3.1)

15 No counterpart - Sudden movement of vehicle, without collision, resulted in injury, sudden braking, sudden swerving, going around a corner too quickly, rollover of vehicle without collision, no counterpart: unspecified.

98 Other specified counterpart - Cable car (not on rails), ice- and land-yacht, ski chair-lift, ski lift with gondola.

99 Unspecified counterpart

T4 - TYPE OF TRANSPORT INJURY EVENT

Definition:

The general nature of the transport injury event and, for a land transport event, where it occurred.

Context:

Transport injury events may involve vehicles that operate on land, on water, or in the air, and the vehicles may be involved in the occurrence of injuries in several ways. Identification of these factors is important for injury prevention. Land vehicles may be involved in traffic injury events, which take place on public highways, streets or roads, or in non-traffic injury event while engaged in off-road transport. In addition, a vehicle may be the site of an injury event that is not related to a collision or crash. Basic information about the nature of the transport injury event is classified using Type of Transport Injury Event, which is based on the information for categories V01 to V99 in Chapter XX of ICD-10. The traffic/non-traffic distinction is necessary for mapping to V01 to V89.

Guide for use:

Code Type of Transport Injury Event for all transport injury events. Select the code that best characterises where or how the injury event occurred. Classify injury events involving more than one kind of transport as follows:

Aircraft and land transport—Air or space transport crash or collision (6)

Aircraft and watercraft—Air or space transport crash or collision (6)

Watercraft and land transport—Water transport crash or collision (5)

Descriptions of land transport injury events do not always use the word traffic to describe an event that took place on a public highway, street or road, and they seldom use the term non-traffic to describe an event that occurred off the road. Therefore, be alert to any information that can help in classifying an event; consult the glossary for definitions of traffic and non-traffic injury events.

If no information exists about where a land transport injury event occurred, code Land transport injury event – document as unspecified whether traffic or non-traffic (3).

Document clearly if the injured person was a passenger in a railway train, rail vehicle, or streetcar that was not operating on a public highway, street or road, and the vehicle was involved in a derailment, collision, or crash. (8)

Document Transport vehicle as site of injury event (4) only if Mode of transport is Railway train or rail vehicle, Streetcar or tram, Watercraft, or Aircraft (T1 8.1, 8.2, 11.n, or 12.n) **and** the vehicle is not involved in a derailment, collision, or crash.

T4 - Type Of Transport Injury Event

1 Land transport traffic injury event - Events occurring on a public highway, street or road

2 Land transport non-traffic injury event - Events occurring entirely in any place other than a public highway, street or road (eg., a child being run over when someone backed up a car in a driveway; a woman falling off her bicycle while riding on a path in the woods; a race car driver crashing at a race track)

3 Land transport injury event – unspecified whether traffic or nontraffic.

4 Transport vehicle is site of injury event - Fall in or from railway train or rail vehicle, streetcar or tram, watercraft, or aircraft (including parachute jumps), carbon monoxide poisoning due to engine malfunction in land transport vehicle, accidental poisoning by gases or fumes on ship, atomic reactor malfunction in watercraft, crushed by falling object on ship or aircraft, excessive heat in boiler room, engine room, evaporator room, fire room on ship, explosion of boiler on steamship, injuries in watercraft caused by deck machinery, engine room machinery, galley machinery, laundry machinery, loading machinery, localised fire on ship, machinery accident in watercraft, injury from machinery on aircraft.

5 Water transport crash or collision

6 Air or space transport crash or collision

8 Other specified type of transport injury event

9 Unspecified type of transport injury event

P - PLACE MODULE

P1 – INDOOR/OUTDOOR

P2 - PART OF BUILDING OR GROUNDS

P3 - TYPE OF HOME

P4 - RESIDENT OF HOME

P5 - TYPE OF MEDICAL SERVICE AREA

P6 - TYPE OF SCHOOL

P7 - INSIDE/OUTSIDE CITY LIMITS

Introduction:

The Place Module provides more detailed information about where the injured person was when the injury event began. The module consists of seven data elements. These elements are listed in the table below, along with the first-level Place of occurrence codes to which they relate.

Guide for use:

Document information on the ICECI Data Collection form that is relevant to each appropriate Place Module data element noted in the medical record.

P1 – INDOOR/OUTDOOR

Definition:

Whether the injured person was inside a building or in the open air when the injury event started.

Context:

This data element is relevant to all main groups of Place of occurrence except Transport area:

public highway, street or road (C4 6) and Countryside (C4 12).

P1 – Indoor/Outdoor

1 Indoor

2 Outdoor

9 Unspecified

P2 - PART OF BUILDING OR GROUNDS

Definition:

The specific part of the building or the specific part of the adjacent grounds where the injured person was when the injury event started.

Context:

In general, Place of occurrence includes whole entities and attached grounds, outbuildings, etc.

This data element provides more information about the place where an injury event began, which may offer insight into aetiology and guide prevention and intervention programs. It is relevant to all main groups of Place of occurrence except Transport area: public highway, street or road (C4 6), Transport area: other (C4 7) and Countryside (C4 12).

P2 - Part Of Building Or Grounds

1 Bathroom, toilet

2 Kitchen

3 Living room

4 Bedroom

5 Playroom/family room

6 Office, home office

7 Classroom

8 Canteen, cafeteria

9 Balcony

10 Stairs

11 Elevator

12 Corridor

13 Lobby

14 Garden, yard - Walled compound, courtyard

Excludes:

- swimming pool (17)
- tennis court (18)
- playground (20)

15 Garage

16 Driveway

17 Swimming pool

18 Tennis court

19 Other specified sporting facility

20 Playground

21 Private road

22 Private parking area

98 Other specified part of building or grounds – Roof, basement.

99 Unspecified part of building or grounds

P3 - TYPE OF HOME

Definition:

The kind of home where the injured person was located when the injury event occurred or commenced.

Context:

This data element is relevant to the main group Home (C4 1) of Place of occurrence. It may provide insight into the types of homes in which particular injuries occur most often, which may help guide strategies for preventing those injuries.

P3 - Type Of Home

1 Detached house

2 Terrace house, row house

3 Apartment, flat - apartment, flat that is part of an apartment building, apartment, flat that is part of a duplex.

4 Farmhouse

5 Residential caravan, mobile home, houseboat, motor home

6 Hut - Refers to an often small and temporary dwelling of a simple construction, built from cardboard, sail, fabric, wood, etc. Cabin, shack, tent, lean-to.

7 Boarding house, hotel

8 Other specified type of home

9 Unspecified type of home

P4 - RESIDENT OF HOME

Definition:

The occupant of the home where the injured person was when the injury event occurred or commenced.

Context:

This data element is relevant to the main group Home (C4 1) of Place of occurrence. It identifies the person responsible for the home where the injury event occurred or commenced. It is especially relevant to injuries resulting from assault.

P4 - Resident Of Home

1 Injured person

Example: a man is injured by falling from a ladder at his own home.

Example: a woman is assaulted by an intruder at her home.

2 Perpetrator (in cases of assault and abuse)

Example: a woman is assaulted by her boyfriend at his home

3 Person other than injured person or perpetrator

Example: a child is injured while visiting her friend's home.

9 Unspecified person

P5 - TYPE OF MEDICAL SERVICE AREA

Definition:

The kind of medical service area where the injured person was when the injury event occurred or commenced.

Context:

This data element is relevant to the main group Medical service area (C4 3) of Place of occurrence. Place of occurrence provides categories for three broad types of medical service areas. It is recognsied that more specific categories will be required for some purposes. National differences in the organisation of health care and in terminology complicate development of a classification that will have wide relevance and acceptability. Hence, at present, this data element is included without a classification in order to provide a basis for users to specify more detailed and nationally relevant classifications of medical service areas.

Guide for use:

Document detail of the type of Medical Service area where the injury occurred.

P5 - Medical Service Area

P6 - TYPE OF SCHOOL

Definition:

The kind of school or educational area where the injured person was when the injury event occurred or started.

Context:

This data element is relevant to the main group School, educational area (C4 4) of Place of occurrence. When combined with the age of the injured person, this data element may provide useful insight into the injury aetiology and help guide prevention and intervention programs.

P6 - Type Of School

1 Child centre, day care centre - day nursery, crèche, after-school care.

2 Preschool, kindergarten

3 Primary school

4 Secondary school

5 College, university

6 Adult education institution

8 Other specified type of school

9 Unspecified type of school

P7 - INSIDE/OUTSIDE CITY LIMITS

Definition:

The specific location—whether inside or outside city limits—where the injured person was when the injury event started.

Context:

This data element is relevant to the main groups Transport area: public highway, street or road (C4 6), Transport area: other (C4 7) of Place of occurrence. In most countries, city limits mark specific responsible agencies, different road conditions, and safety measurements (eg. Speed limits).

P7 - Inside/Outside City Limits

1 Inside city limits

2 Outside city limits

9 Unspecified location of transport area

S - SPORTS MODULE

S1 - TYPE OF SPORT/EXERCISE ACTIVITY

S2 - PHASE OF ACTIVITY

S3 - PERSONAL COUNTERMEASURES

S4 - ENVIRONMENTAL COUNTERMEASURES

Introduction:

The Sports Module provides additional information about what the injured person was doing when the injury occurred. Specifically, its four data elements—Type of sport/exercise activity, Phase of activity, Personal countermeasures and Environmental countermeasures—add detail about sports-related activities the injured person was engaged in.

Context:

The Sports Module is relevant to the following codes under Activity when injured: Paid work (1.2), in the case of a professional sports activity or a sports activity performed under the auspices of an employer; Physical education class or school-related sport (3.1); and Sports and athletics area during leisure time (4).

Guide for use:

Document all information for each relevant data element noted in the code for Activity when injured, provide as is available.

S1 - TYPE OF SPORT/EXERCISE ACTIVITY

Definition:

The type of sport or exercise activity in which the injured person was engaged at the time of the injury. Participation in a sport or exercise activity includes practice, training, and competition, as well as pre-event (eg., taping, dressing), warm-up, cool down, and post-event (eg., showering, dressing) activities. It does not include travel to and from the event or activity.

Context:

This detailed classification of sports and exercise activities will facilitate the comparison of particular activities and injuries across time and location. In addition, this information may highlight particular problem areas or injuries for future prevention efforts.

Guide for use:

To document information on Type of Sport/Exercise Activity:

Document the sport or exercise activity engaged in at the time of injury with as much specificity as possible. Where the documentation does not allow the specific description of a sport refer to the broad categories listed below.

For example: Injured person hit by bat while participating in sports carnival. (Team bat or stick sport)

Indicate individual participation in an activity related to a team sport as that team sport. For example, if an injury occurs while an individual is shooting a basketball alone, document the sport as Basketball (1.01).

Document training for a particular sport as that sport. For instance, if a participant is injured while weight training during football practice, document the sport as Football – American tackle (1.02), rather than Strength training/body building (13.03).

Notes:

The 3rd and 4th editions of the Australian clinical modification of ICD-10 includes an expanded Activity classification based on this item. The categories listed below are the broadest categories of sports activities. Data collectors should document as much detail on the sport, phase of activity etc that is possible from documentation in the medical record.

S1 – Type Of Sport/Exercise Activity

1 Team ball sports- Beach and outdoor volleyball, two-, four-, and six-player volleyball, indoor volleyball, walleyball, other specified, unspecified team ball sport.

2 Team bat or stick sports

3 Team water sports

4 Boating sports

5 Individual water sports

6 Ice or snow sports

7 Individual athletic activities

8 Acrobatic sports

9 Aesthetic activities

10 Racquet sports

11 Target/precision sports

12 Combative sports

13 Power sports

14 Equestrian activities

15 Adventure sports

16 Wheeled motor sports

17 Wheeled non-motored sports

18 Multidiscipline sports

19 Aero (non-motored) sports

20 Other school-related recreational activities - School physical education class, school free play, informal play at school, activities during recess, other specified, unspecified school sport/exercise activity.

98 Other specified sport/exercise activity

99 Unspecified sport/exercise activity

S2 - PHASE OF ACTIVITY

Definition:

The phase of a sport or exercise activity during which the injury occurred.

Context:

This data element will help to identify the particular phase of a sport or exercise activity during which an injury occurred. Sorting injuries by phase of activity may facilitate a better understanding of injury mechanisms and prevention strategies. The timing of an injury during competition or time-limited participation should be gathered to the level of detail available.

Guide for use:

Document information that most accurately and narrowly describes the phase of activity. For injuries that occur during activities without a clear delineation between Training/practice and Competition/participation (eg., jogging, recreational cycling), provide documentation to identify it as Recreational participation (7).

S2 - Phase Of Activity

1 Training/practice - Injuries occurring in training or practice for a competitive activity, sport-specific or skill-specific practice, running drills, scrimmaging, practising the sport by playing against others (not in competition), strength and conditioning/weight training, push ups, sit ups, pull ups, resistance exercises, cardiovascular training, jogging, aerobics, riding a stationary bike, other specified, unspecified training/practice.

Excludes:

Injuries occurring in recreational (non-competitive) activities (7)

2 Pre-event - Any activity occurring after transport to an event but before warm-up, dressing, taping, showering.

3 Warm-up - Any physical activity performed to warm up muscles immediately before competition or participation, stretching, jogging, light scrimmaging.

4 Competition/participation - If an event has a scheduled beginning and ending, code the stage of event to the level of detail available.

- **First 25% of expected event duration -** First quarter of a football game, first 100 metres of a 400-metre race.
- **Middle 50% of expected event duration -** Second or third quarter of a football game, second or third 100 metres of a 400-metre race.
- **Last 25% of expected event duration -** Fourth quarter of a football game, last 100 metres of a 400-metre race.
- **Other (for events whose time course can not be anticipated)**
- **Unspecified stage of the event**

5 Cool down - Any physical activity performed to cool down muscles immediately after participation or competition, stretching, jogging, light scrimmaging.

6 Post-event - Any activity occurring after cool down but before transport away from the event, showering, dressing.

7 Recreational participation - For injuries that occur during activities without a clear delineation between Training/practice (1) and Competition/participation (4), jogging, walking, non-competitive cycling.

8 Other specified phase or activity - horsing around, fooling around.

9 Unspecified phase or activity

S3 - PERSONAL COUNTERMEASURES

Definition:

Equipment used or worn by a participant to protect against injury. Does not include environmental safety devices.

Guide for use:

This data element may have more than one relevant item that can be coded in ICECI.

Dopcument all personal protective equipment used, whether or not directly related to the body part injured.

For example: Documentation should include mouth guards if used, even if the injury did not occur to the teeth or mouth.

S3 - Personal Countermeasures

1 No protective devices used

2 Braces, guards, orthoses - knee, ankle, and shin braces and guards, orthotic shoe inserts and ankle orthoses.

3 Rigid taping of joint

4 Padding of joint, bony prominence, or muscle

5 Thermal devices – Thermoskin, wetsuit.

6 Splints

7 Jock strap, protective cup

8 Gloves

9 Mouth guard

10 Eye goggles/protective glasses

11 Helmet

12 Face mask/shield

13 Foot wear - Hard-toed shoes/boots, appropriate cleats.

14 Personal flotation device

98 Other specified personal countermeasure

99 Unspecified personal countermeasure

S4 - ENVIRONMENTAL COUNTERMEASURES

Definition:

Measures in the competitive or recreational environment that are designed to protect against injury. Does not include protective equipment worn or used by participants, except in the case of vehicle safety restraints.

Guide for use:

Information relevant to this data element may result in the assignment of more than one relevant ICECI code.

Document all the items from the list that were known to be in the environment at the time and location of the injury, whether or not directly related to the body part injured.

S4 - Environmental Countermeasures

1 No protective devices used

2 Protective padding on competition surface - Padded high jump pits, judo mats.

3 Padded goal posts, corner markers

4 Barrier between area of activity and spectators/surrounds

5 Safety restraints/vehicle restraints – Ropes, harnesses, safety belts.

8 Other specified environmental countermeasure

9 Unspecified environmental countermeasure

O - OCCUPATIONAL MODULE

Introduction:

The Occupational Module provides more information about the circumstances and setting of injuries that occur while a person is performing paid work**.** The current draft of the module consists of two data elements: Economic activity and Occupation.

Context:

The data in this module can help guide efforts to prevent occupational injuries. Taken together,

Economic activity data and Occupation data can help reveal exposure to unsafe working conditions, identify risk groups, and determine the responsible sector for injury prevention.

Guide for use:

Document information relevant to both data elements in this module for all injuries related to paid work.

O1 - ECONOMIC ACTIVITY

Definition:

The type of industry or business in which the injured person was working at the time of injury.

Context:

Knowing the type of industry or business the injured person was working in can help practitioners develop interventions to prevent work-related injuries.

Guide for use:

For all injuries related to paid work, provide documentation that best describes the industry or business in which the injured person was involved.

Notes:

The economic activity codes are based on the International Standard Industrial Classification of All Economic Activities (ISIC), Revision 3 (United Nations, 1990). For detailed information, coding instructions, and inclusions and exclusions, look at http://esa.un.org/unsd/cr/registry/regct.asp.

O1 - Economic Activity

1 Agriculture, hunting, or forestry

- growing of crops; market gardening; horticulture
- farming of animals
- growing of crops combined with farming of animals (mixed farming)
- agricultural and animal husbandry service activities
- hunting, trapping and game propagation including related service activities
- forestry
- logging and related service activities

Excludes:

- veterinary activities (14)

2 Fishing

Operation of fish hatcheries and fish farms

Service activities incidental to fishing

3 Mining, quarrying, extraction

- mining of coal and lignite
- extraction of peat
- extraction of crude petroleum and natural gas
- service activities incidental to oil and gas extraction

 mining of uranium and thorium ores

 mining of metal ores

 quarrying of stone, sand and clay

4 Manufacturing

 food products and beverages

 tobacco products

 textiles

 wearing apparel; dressing and dyeing of fur

 tanning and dressing of leather; luggage, handbags, saddlery, harness and footwear

 wood and products of wood and cork

 articles of straw and plaiting materials

 paper and paper products

 publishing, printing and reproduction of recorded media

 coke, refined petroleum products and nuclear fuel

 chemicals and chemical products

 rubber and plastics products

 other non-metallic mineral products

 basic metals

 fabricated metal products

- machinery and equipment
- office, accounting and computing machinery
- electrical machinery and apparatus
- radio, television and communication equipment and apparatus
- medical, precision and optical instruments, watches and clocks
- motor vehicles, trailers and semi-trailers
- other transport equipment
- furniture
- recycling

5 Electricity, gas, or water supply

- electricity gas, steam and hot water supply
- collection, purification and distribution of water

6 Construction

- site preparation
- building of complete constructions or parts thereof
- civil engineering
- building installation
- building completion

- renting of construction or demolition equipment with operator

7 Wholesale or retail trade; repair of motor vehicles, motorcycles, or personal and household goods

- wholesale of agricultural raw materials, live animals, food, beverages and tobacco
- wholesale of household goods
- wholesale of machinery, equipment and supplies
- retail sale of food, beverages and tobacco
- retail sale of pharmaceutical and medical goods, cosmetic and toilet articles
- retail sale of textiles, clothing, footwear and leather goods
- retail sale of household appliances, articles and equipment
- retail sale of hardware, paint and glass
- retail sale of second-hand goods
- retail sale via mail order houses
- retail sale via stalls and markets
- sale of motor vehicles
- maintenance and repair of motor vehicles
- sale of motor vehicle parts and accessories
- sale, maintenance and repair of motorcycles and related parts and accessories
- retail sale of automotive fuel

- repair of personal and household goods

8 Hotels and restaurants

- hotels
- camping sites and other provision of short-stay accommodation
- restaurants
- bars
- canteens

9 Transport, storage, or communications

- land transport
- transport via pipelines
- water transport
- air transport
- supporting and auxiliary transport activities
- activities of travel agencies
- post and telecommunications

10 Financial intermediation

- central banking

- insurance and pension funding

11 Real estate, renting, or business activities

- real estate activities
- renting of transport equipment
- renting of personal and household goods
- hardware consultancy
- software consultancy and supply
- data processing
- maintenance and repair of office, accounting and computing machinery
- research and development
- legal, accounting, book-keeping and auditing activities
- tax consultancy
- market research and public opinion polling
- business and management consultancy
- architectural, engineering and other technical activities
- advertising
- labour recruitment and provision of personnel
- investigation and security activities
- building-cleaning activities

- photographic activities
- packaging activities

12 Public administration, defence, or compulsory social security

- administration of the state
- economic and social policy of the community
- foreign affairs
- defence activities
- public order and safety activities
- compulsory social security activities

13 Providing education

- primary education
- secondary education
- higher education
- adult and other education

14 Health or social work

- human health activities
- veterinary activities

- social work activities

15 Other community, social, or personal service activities

- sewage and refuse disposal, sanitation and similar activities
- activities of business, employers and professional organisations
- activities of trade unions
- activities of religious organisations
- activities of political organisations
- motion picture, radio, television and other entertainment activities
- news agency activities
- library, archives, museums and other cultural activities
- sporting and other recreational activities
- washing, and (dry-) cleaning of textile and fur products
- hairdressing and other beauty treatment
- funeral and related activities

16 Private households with employed persons

- maids
- cooks
- waiters

- valets
- butlers
- laundresses
- gardeners
- gatekeepers
- stablehands
- chauffeurs
- caretakers
- baby-sitters and tutors
- secretaries

17 Extra-territorial organisations and bodies

- World Health Organization
- United Nations
- European Communities
- Organization for Economic Co-operation and Development
- Organization of African Unity
- League of Arab States
- International Monetary Fund
- World Bank

98 Other specified economic activity

99 Unspecified economic activity

O2 - OCCUPATION

Definition:

The type of paid work the injured person was engaged in when the injury event took place.

Context:

Data about the type of work an injured person was performing can help guide development of interventions to prevent occupational injuries.

Guide for use:

For all injuries related to paid work, provide documentation that best describes the type of work in which the injured person was involved.

Notes

The occupation codes are based on the International Standard Classification of Occupations,

ISCO-88 (ILO, 1990). For detailed information, coding instructions, and inclusions and exclusions, look at http://www.ilo.org/public/english/bureau/stat/class/isco.htm.

O2 - Occupation

1 Legislators, senior officials, managers

- legislators
- senior government officials
- traditional chiefs and heads of villages
- senior officials of special interest organisations
- directors and chief executives
- production and operations department managers
- general managers

2 Professionals

- physicists, chemists and related professionals
- mathematicians, statisticians and related professionals
- computing professionals
- architects, engineers and related professionals
- life science professionals
- health professionals
- nursing and midwifery professionals
- teaching professionals
- business professionals
- legal professionals

- archivists, librarians and related information professionals
- social sciences and related professionals
- writers and creative or performing artists
- religious professionals

3 Technicians or associate professionals

- physical and engineering science technicians
- computer technicians
- optical and electronic equipment operators
- ship and aircraft controllers and technicians
- safety and quality inspectors
- life science technicians
- modern health technicians and associate professionals
- traditional medicine practitioners and faith-healers
- teaching technicians and associate professionals
- finance and sales associate professionals
- business services agents and trade brokers
- administrative associate professionals
- customs, tax and related government associate professionals
- police inspectors and detectives

- social work associate professionals
- artistic, entertainment and sports associate professionals
- religious associate professionals

4 Clerks, secretaries

- office clerks
- numerical clerks
- material-recording and transport clerks
- library, mail clerks
- tellers
- client information clerks

5 Service workers, shop and market sales workers

- travel attendants
- housekeeping and restaurant services workers
- personal care workers
- astrologers, fortune-tellers
- protective services workers
- fashion and other models
- shop salespersons and demonstrators

- stall and market salespersons

6 Skilled agriculture or fishery workers

- market gardeners and crop growers
- animal producers and related workers
- crop and animal producers
- forestry workers
- fishery workers, hunters and trappers

7 Craft or related trades workers

- building trade workers (eg. bricklayer, carpenter, painter)
- miners, stonecutters and carvers
- metal machinery workers (eg. welders, sheet-metalworkers, blacksmith)
- precision workers in metal
- potters, glass-makers
- handicraft workers in wood, textile, leather
- printing trades workers
- food processing trades workers
- wood treaters, cabinet-makers
- textile, garment trades workers

- felt, leather and shoemaking trades workers

8 Plant/machine operators or assemblers

- mining and mineral-processing plant operators
- metal-processing plant operators
- glass, ceramics plant operators
- wood processing and papermaking plant operators
- chemical processing plant operators
- power production plant operators
- automated assembly-line and industrial robot operators
- metal and mineral products machine operators
- chemical, rubber and plastic products machine operators
- wood products machine operators
- printing, binding and paper products machine operators
- textile, fur and leather products machine operators
- food products machine operators
- assemblers
- locomotive engine-drivers
- motor vehicle drivers
- agricultural and other mobile plant operators

- ships' deck crews

9 Elementary occupations

- street vendors
- shoe cleaning
- domestic helpers, cleaners and launderers
- building caretakers, window cleaners
- messengers, porters, doorkeepers
- garbage collectors
- agricultural, fishery and related labourers
- mining and construction labourers
- manufacturing labourers
- transport labourers and freight handlers

10 Armed forces

98 Other specified occupation

99 Unspecified occupation

APPENDIX 6 ETHICS APPOVAL – MEDICAL RECORD REVIEW

Queensland Government

Queensland Health

Enquiries to: Jane Jacobs, Research & Ethics, Clinical Practice Improvement Centre
Telephone: (07) 322 52457
Facsimile: (07) 322 17535
Our Ref: 2006/013

Dr Kirsten McKenzie
National Centre for Classification in Health (NCCH)
Queensland University of Technology
Faculty of Public Health
Victoria Park Rd
KELVIN GROVE QLD 4059

Dear Dr McKenzie,

2006/013 - Assessing the Concordance of Coded Trauma Data: Comparing Trauma Registry Data, Hospital Records and Death Certificate

At a meeting of the Queensland Health Research Ethics Committee (QHREC) held on 21 August 2006, the Committee reviewed the above Protocol. The Queensland Health Research Ethics Committee (QHREC) is duly constituted, and operates and complies with the National Health and Medical Research Council's 'National Statement on Ethical Conduct in Research Involving Humans and Supplementary Notes, 1999'.

It is advised that the Committee is satisfied with the ethical aspects of the present proposal. During the conduct of the study you are required to adhere to the following conditions:

- The National Statement on Ethical Conduct in Research Involving Humans requires a Human Research Ethics Committee to nominate a person to whom complaints from participants, researchers, or other interested persons can be directed. The QHREC has nominated Senior Director, Clinical Practice Improvement Centre (Phone 3636 9768). This information must be included in the Information Sheet provided to participants.
- The clearance number should be quoted on all correspondence relating to ethical clearance.
- All forms required when submitting reports to the QHREC are accessible on the internet site (**www.health.qld.gov.au/ethics**). In the first instance please access the Commencement Form and return to this office when the study commences. Please contact the Coordinator if you do not have access to this site.
- You are required to provide a report on the outcome of the study at the completion of the study or annually if the study continues for more than 12 months.

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(07) 322 17535

- You must immediately report to the QHREC any serious or unexpected event involving participants, and any unforseen events that might affect continued ethical acceptability of the project. In addition, the Investigator must provide a summary of the adverse events, in the specified format, including a comment as to suspected causality and whether changes are required to the Patient Information and Consent Form.
- If any subsequent change/amendment is made to the protocol it will be necessary for you to obtain approval from the QHREC. The amended documents must be accompanied by a letter, signed by the Principal Investigator, providing a brief description of the changes, the rationale for them and their implications for the ongoing conduct of the study. All amended documents must contain revised version numbers, version dates and page numbers. Changes must be highlighted using Microsoft Word "Track Changes" or similar.
- Copies of all publications resulting from the study should be submitted to the QHREC. Please also ensure that a copy is also forwarded to the appropriate Hospital Medical Library for future reference.

The Queensland Health Research Ethics Committee provides advice on the ethical acceptability of a research proposal. However, Health Service District Managers have the responsibility to approve research projects being carried out in their district. The District Manager will base his/her decision on institutional ethical, legal and where relevant financial implications, in addition to any local issues.

Therefore, before commencing any research you will need to contact each relevant local HREC, or if none exist, the Health Service District Manager, providing a copy of the research protocol and the QHREC Letter of Acceptance. It is the HREC's responsibility for monitoring your research activities in their district.

The QHREC wishes you every success in undertaking this research project.

Yours sincerely

Professor M J Eadie
Chair, Queensland Health Research Ethics Committee
23 August 2006

Queensland Government

Queensland **Health**

Enquiries to:	Principal Advisor Research and Ethics Advisory Unit
Telephone:	(07) 3225 2457
Facsimile:	(07) 3221 7535
File Ref	DG048058/0007843

Dr McKenzie
National Centre for Classification in Health
Queensland University of Technology
Victoria Park Rd
KELVIN GROVE QLD 4059

Dear Dr McKenzie

It is with pleasure that I am writing to inform you that your request to access confidential health information for the project '*Developing and Enhancing the Quality of National Injury-Related Hospital Morbidity Data*' has received approval from the Chief Executive, Queensland Health, under section 281 of the *Public Health Act 2005*. In accordance with this legislation, this approval enables the applicants listed in your application to access and use the specified confidential information, providing they act within the limits detailed in your application submitted in April 2007.

Please display this letter, a signed copy of the Undertaking of Confidentiality and a copy of your application when requesting the confidential information from the relevant information gatekeepers.

The date of approval for access to and use of this confidential information commences from 10 April 2007 and will extend for 5 months until the 30 September 2007. Should you wish to extend your research project beyond this time, or wish to disclose this information to additional people, you will need to re-apply for further approval for the release of confidential data by the same process.

Congratulations and good luck with the research project.

Yours sincerely

Jeannette Young

Dr Jeannette Young
Acting Director-General
22 / 05 / 2007

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APPENDIX 7 PUBLISHED JOURNAL ARTICLES RELATING TO THESIS

“Knowing is not enough; we must apply.

Willing is not enough; we must do”

(Johann Wolfgang von Goethe)